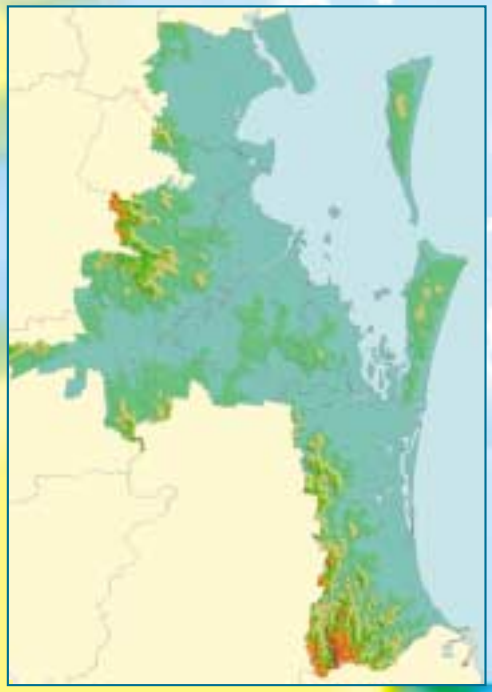
Natural Hazards & the risks they pose to *South-East* QUEENSLAND



Edited by K. Granger and M. Hayne

Produced by **AGSO – Geoscience Australia**
in conjunction with the **Bureau of Meteorology**

AGSO
GEOSCIENCE AUSTRALIA

BUREAU OF METEOROLOGY

Department of Industry, Science and Resources

Minister for Industry, Science and Resources

Senator the Hon.Nick Minchin

Parliamentary Secretary: The Hon.Warren Entsch MP

Secretary: Russell Higgins

AGSO – Geoscience Australia

Chief Executive Officer: Neil Williams

ISBN: 0 642 46708 0

DISCLAIMER

The information is provided for mitigation of natural hazards and risks posed to South-East Queensland. The Commonwealth does not warrant that the information in the report is accurate or complete, and disclaims liability for all loss, damages and costs incurred directly or indirectly by any person as a result of using or relying on the information in the report.

AGSO GEOSCIENCE AUSTRALIA

Produced in conjunction with

Bureau of Meteorology
Department of the Environment and Heritage

and in cooperation with

Queensland Government
Natural Resources and Mines

Queensland Government
Department of Emergency Services

Redland Shire Council

CSC Caboolture Shire Council

Gold Coast City Council

Brisbane City

Redcliffe City Council

Logan City Council

Pine Rivers

Ipswich City Council

FOREWORD

AGSO – Geoscience Australia is Australia's leading national geoscience research organisation. The AGSO Cities Project assesses the effects on urban communities of a range of natural hazards. In South-East Queensland these are cyclones, east coast lows, thunderstorms, severe winds, floods, earthquakes, landslides, heat waves, and bushfires. AGSO – Geosceince Australia is grateful for the collaboration of the Bureau of Meteorology.

While the South-East Queensland study is the third in a series of multi-hazard risk assessments, it is the first to cover such a large area and population, and such a wide range of hazards. It has built on risk assessment methods used in Cairns and Mackay, but new techniques have also been developed.

This booklet contains interesting information on the risks posed by natural hazards in South-East Queensland. It includes summaries of the assessed risk, and some fascinating historical examples. It is an introduction to the full multi-hazard risk assessment, *Natural hazards and the risks they pose to South-East Queensland*, which is available on compact disk.

The results of the risk assessment will be useful to people involved in mitigating or responding to the effects of these hazards in South-East Queensland. This will help to make communities safer, and consequently more sustainable and prosperous. The report will also be of interest to people wanting to find out more about the hazards themselves and the risks they pose, and to researchers involved in risk assessment.

I urge you to look at the full report on the compact disk. It is important, groundbreaking work and I commend it to you.

The Hon. Warren Entsch MP

Parliamentary Secretary to the Minister for Industry, Science and Resources

Parliament House
Canberra ACT 2600

Queensland is the most disaster prone state in Australia. While the Queensland Government, through the Department of Emergency Services, leads Australia in its disaster mitigation initiatives, it's clear there can be no room for complacency.

The fact that South-East Queensland has been relatively free of significant impact in recent times should not obscure the real risks faced by this heavily populated and fast growing region.

The South-East region is culturally, economically and environmentally essential to Queensland's future.

Preparing, planning and understanding our response to any future risk of natural disasters in this region is vital.

AGSO – Geoscience Australia's report *Natural Hazards and the risks they pose to South-East Queensland* provides a comprehensive overview of the natural hazard risks faced by people, communities, infrastructure and organisations across the region.

The report, provided on a compact disk, promotes community awareness and understanding of the natural hazards and their risk in the region. The natural hazards, which are considered in the study, including tropical cyclones, east coast lows (winter cyclones), floods, earthquakes, landslides, severe thunderstorms, heatwaves and bushfires, have all impacted within this region in the past. As many would recall, a number of these impacts have had devastating effects, such as the 1974 Brisbane floods and the 1985 hailstorm.

This booklet provides a summary of the findings of the full report and highlights the range and severity of potential natural disaster impacts on South-East Queensland.

The Queensland Government, through the Department of Emergency Services, has been pleased to work with the Commonwealth and Local Governments through the development of this important project.

This report will, in combination with my Department's range of initiatives, define and quantify the risks and develop policies and programs to mitigate the potential impacts, as well as assist the development and maintenance of safer communities.

I urge all Local Governments, communities, organisations and individuals to benefit from the information provided.

THE HONOURABLE MIKE REYNOLDS AM MP

Queensland Minister for Emergency Services
Minister Assisting the Premier in North Queensland

Our wonderful natural environment in South-East Queensland attracts thousands of visitors and residents every year. However natural hazards like floods, fires, storms, cyclones and heatwaves, can potentially devastate our lives and lifestyles.

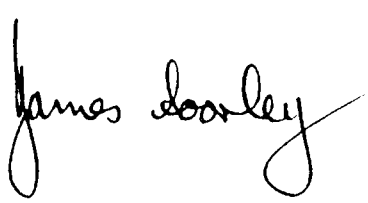
Much of the loss of life and property during natural disasters is avoidable with adequate preparation and warning. This requires that resources for these tasks are both adequate and properly distributed.

This excellent report by AGSO – Geoscience Australia assesses both the actual and relative risk from natural hazards. It will greatly help the South-East Queensland's local governments to properly distribute resources according to relative risk. However, where resources are inadequate, it will have implications for other levels of government because of local governments' limited revenue raising capacity, and the strategic social and economic implications of natural disasters.

The report is impressive in it its thoroughness, taking account of such details as the types of buildings. Surprisingly, old wooden Queenslanders may be more resilient to certain hazards than some new brick veneer houses. The report points out the additional risk resulting from the lack of uniform State laws on building in flood prone areas.

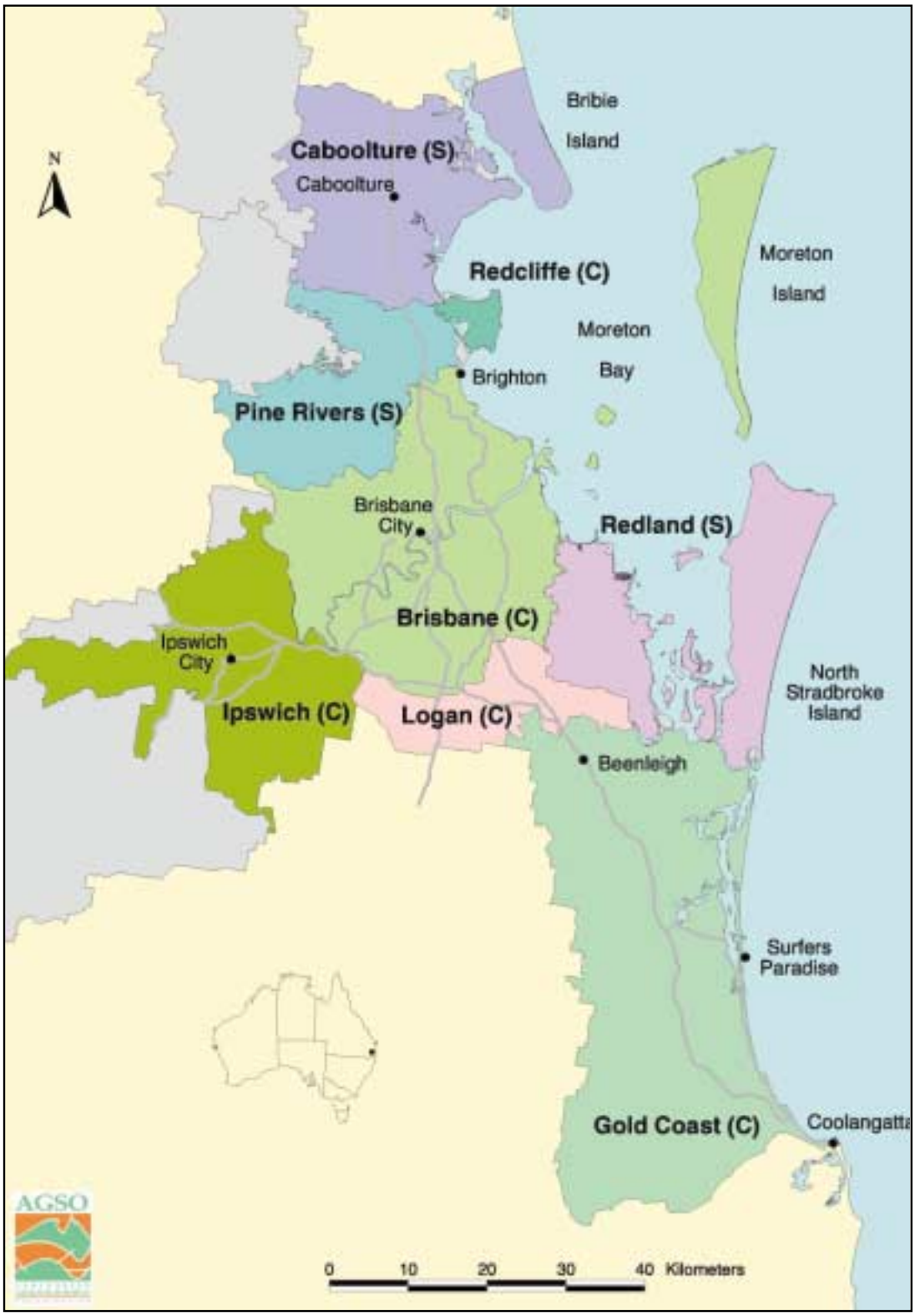
In fact, flooding is clearly the major natural risk we face. It costs Australia $200 million annually; half that cost is incurred in Queensland. It could be exacerbated by many factors, including vegetation loss, extensive hard surfacing and possibly climate change. Fortunately, these factors may be offset by new techniques for using water sensitive urban design, rainwater tanks and natural channelling.

The authors have done the hard yards in looking at the risks posed by the natural hazards of our region. Federal, State and local governments must now work together to address its implications.



Jim Soorley

Lord Mayor of Brisbane
Chair, South East Queensland Regional Organisation of Councils



South-East Queensland study area extent and location

BACKGROUND

The AGSO Cities Project was established in 1996 to undertake research directed towards the mitigation of the risks faced by Australian urban communities that are posed by a range of geohazards. Geohazards are broadly defined to include all earth surface processes with the potential to cause loss or harm to the community or the environment. The ultimate objective is to improve the safety of communities, and consequently make them more sustainable and prosperous. The Cities Project is using a series of case studies in Australian cities to develop and test its science and techniques. South-East Queensland is the third of these multi-hazard case studies. It builds on multi-hazard risk assessment work already published by AGSO on Cairns in 1999 and Mackay in 2000.

The South-East Queensland region covered in this study is one of Australia's fastest growing urban regions and is already home to almost 2 million people. The study area covers around 5230 sq km, extending about 150 km from north to south and 110 km, westward from the coast, and takes in the following areas:

- the eastern urbanised portions of Caboolture and Pine Rivers Shires;
- the north-eastern urbanised portion of Ipswich City; and
- the complete areas of Redcliffe, Brisbane, Logan and Gold Coast Cities and Redland Shire.

INTRODUCTION

The modern landscape of South-East Queensland is the result of millions of years of interaction between the most violent forces of nature. The mountains of the hinterland were thrust up by massive tectonic movement or laid down by the eruption of massive volcanoes. The coastal plains have been shaped by the action of the streams and rivers that have eroded them to their present elevation through flood after flood. The coastline has been shaped by the huge seas that accompany cyclones and other large storms. Even the vegetation has evolved to cope with the periodic fires started by lightning or the Aboriginal tribes that first occupied the area some 20 to 30 000 years ago.

Even over the relatively brief period in which Europeans have occupied the area, changes to the landscape have been significant. The mouth of the Nerang River, for example, has moved north about five kilometres over the past 100 years, whilst the dune build-up that forms the spit, on which Sea World now stands, did not occur until the 1920s. We have endeavoured to limit the impact of the forces of nature by building dams to 'control' flooding; we have reinforced the shoreline with rock or concrete to 'arrest' coastal erosion; we have filled in large areas of wetland to create valuable land on which to build the international airport, port facilities and residential developments; we have even built artificial reefs to 'protect' our ocean beaches.

More importantly, we tend to make the assumption that because we have not had a serious natural disaster in the region now for at least 27 years that South-East Queensland does not face any significant risks from natural hazards. Such a view is common in Australia where we tend to think that we live in a very benign environment. We do not suffer the losses from cyclones and floods experienced in countries such as China or Bangladesh, nor are we exposed to the threat of great earthquakes, like those experienced in recent times in Chile, the west coast of the USA, Japan, Taiwan and Turkey.

Australia, however, is far from immune from the impact of significant natural disasters, given that such events cost the Australian community around $1.14 billion annually. The recent Bureau of Transport Economics (BTE) study into the economic costs of natural disasters in Australia (BTE, 2001) shows that during the period 1967 to 1999, Queensland experienced 71 major disasters with a total estimated cost of $7.9 billion (1999 dollar value), second only to the NSW total of $16.0 billion from 83 major disasters. It should be remembered, however, that for the last 25 years of this 34 year period, Queensland has been relatively free of major cyclone and flood disasters.

We tend to ignore the experience of history, especially where it has caused us pain and loss. The disaster history of South-East Queensland, however, provides both a clear pointer as to what can and will happen in the future and it gives us a clear indication of what we as individuals and as communities can do to minimise their impact when they do occur. Reducing risk and making our communities even safer and more sustainable than they are today is something that we can all play a part in.

FLOODS

In the last century, the Australia Day floods of 1974 were the worst period of flooding across the South-East Queensland region, although the 1931 floods were probably more severe locally in the Caboolture and Pine Rivers catchments. The floods of the mid and late 1800s recorded water levels substantially higher than the 1974 flood, however, a smaller population, fewer buildings and less infrastructure suggests that damage losses were comparatively small.

The floods of 1841 and 1893 both reached over 8 m above mean sea level on the Brisbane City gauge located at the river end of Edward Street. This represented a depth above highest tide level of approximately 6.5 m. On the Bremer River at Ipswich, the February 1893 flood measured 24.5 m at its peak. This flood followed a massive rainfall in the headwaters of the Stanley and Brisbane Rivers. On 3 February 1893, Inigo Jones recorded 907 mm of rain in 24 hours observatory at Crohamhurst, near the head of the Stanley River - a fall that remains the Australian record.

Brisbane, February 1893 - Flooding in Melbourne St., South Brisbane
(Photo: courtesy of John Oxley Library)

Logan, January 1974 - One of the houses lost during the 1974 flood in Tygum Lagoon area, Waterford West. The site is now a council park *(Photo: J. Ebbelinghaus)*

A contemporary account (Brisbane Courier, 6 February, 1893) illustrates the impact of that flood in Brisbane as follows:

> *Dwelling houses commenced to come down the river in earnest at about 3.30 p.m. on Saturday, and from that time on to Sunday night fully 100 houses and large sheds must have passed the bridge. It was marvellous to see the way in which even the largest dwellings were crushed up against the piers and girders. All the houses which had previously been wrecked floated down square, with their corrugated iron roofs showing. On contact with the bridge the edifices were crushed up instantly. The crushing sound - heard for a mile - told its own tale of misfortune. So continuous and terrible was the crashing of houses on Saturday night that many persons living near the bridge found it impossible to sleep, what with the noise and the consciousness of other people's misfortune. Most of the houses were furnished and no-one could say with certainty that some of them were not occupied by human beings, who were thus hurled to eternity without the power to make the slightest effort to save themselves. At Toowong on Saturday night screams were frequently heard from across the river. A resident of Toowong informs us that from Emma Street a row of three houses could be seen on the south side. Loud noises as of timber collapsing were heard at about 10 p.m. on Saturday, and a light was seen in one of the houses. A minute later the three houses had gone.*

Since 1893, the largest flood in the Brisbane-Bremer system was that caused by tropical cyclone Wanda in January 1974. The same system was also responsible for the most severe twentieth century flooding in the lower reaches of the Albert and Logan River system and the Nerang River. Although a flood of smaller magnitude than the 1893 floods, its impact remains the most severe example of urban flooding in Australia to date.

The 1974 flood caused widespread damage in Brisbane and Ipswich. Flooding from the Brisbane River alone was reported, at the time, as causing at least $200 million worth of damage. A minimum of 13 000 properties were affected. This figure does not include flood losses in Brisbane resulting from the various local creek catchments, and the severe flooding of the Bremer River affecting Ipswich.

Brisbane, 28 January 1974 - Aerial view of Brisbane City showing the extent of flooding in the Brisbane Botanical Gardens (bottom left) up to Elizabeth St. *(Photo: courtesy of John Oxley Library)*

A number of contemporary accounts indicate the impact of the 1974 flood in the Brisbane-Bremer catchment and on the region as a whole. For example, the *Telegraph* of 26 January, 1974 reported:

> *Floodwaters lapped the main Brisbane Airport runways today....trains did not run....the Brisbane City Council has appealed to people not to use buses because services might be cancelled.....Brisbane airport is closed with no indication of when it might open....Floodwaters have cut the Bruce Highway, isolating Gympie from the south.....No trains would be running for an indefinite period, a spokesman for the Railways said today. He said that railway lines at Mayne and at Albion were completely under water with depths of more than 1.2 m (4 ft.). A bridge has collapsed between Wacol and Darra. Both suburban and country trains have been discontinued.....Hundreds of people were evacuated from rooftops by a fleet of speedboats. Record flooding was reported in the Enoggera Creek at the Enoggera Reservoir. Most suburbs were blacked out during the night.....Flooding is expected to increase to record levels in all creek systems today as the rain keeps falling. The worst hit are Moggill Creek, Enoggera-Breakfast Creek, and Kedron Brook.*

The *Courier-Mail,* on 29 January, 1974:

> *The raging Brisbane River continued to rip the heart out of the near-crippled city, tearing vessels from their moorings and washing into more than a dozen suburbs causing disruption to essential services. Several areas were without electricity, water and gas. The flood virtually paralysed the city, cutting most major roads and badly damaging scores of others. The city's commuters face a grim task this morning getting to work because bus and rail services are restricted severely.....Some major city department stores have told their employees to stay home. There were fears last night that the floods may cause food shortages. Huge quantities of food were lost yesterday when waters swamped warehouses in the Brisbane and Ipswich areas. Water feet deep flowed through parts of the inner city causing huge losses to stores and warehouses in the Mary Street - Albert Street area. Soldiers and firemen worked for hours pumping water from the main Edison telephone exchange in Elizabeth Street where floodwater threatened to ruin equipment.....The Weather Bureau expects the Brisbane River to flow at its flood height of 6.7 m (22 ft.) for 16 hours until about 4 p.m. today. The level will be about 2.7.m (9 ft.) below the record height in 1893.....State Government authorities estimated last night that about 5000 people are homeless in the city. The worst hit suburbs yesterday included Jindalee, Sherwood, Indooroopilly, Yeronga and Milton. But police said most southern and western suburbs had been affected. Some of the people moved by boat during the day had only just returned to their flood ravaged homes when the waters rose again, trapping them. More than 30 relief centres operated in the city last night to house and feed the flood victims.*

Ipswich, 28 January 1974 - Looking down East St. to the north, near the intersection with Limestone St., towards David Trumpy Bridge
(Courtesy of Hughes collection, Ipswich Historical Society. Photo: A Wright)

The *Australian*, of 31 January 1974 stated:

> *The death toll mounted to 15 yesterday in the worst floods in Brisbane and the Gold Coast this century. Police fear more bodies will be uncovered as the massive clean up begins. Police yesterday recovered three bodies in the South Brisbane area, one of the worst hit parts of the flood-torn city.*

The *Telegraph*, of 4 February 1974 gave the following grim statistics:

> *.... 2000 houses in Brisbane and 700 in Ipswich still were unfit for habitation.....Mr Bjelke-Petersen said the survey showed that some 8000 houses in Brisbane had been damaged, submerged or destroyed. Proportionately, Ipswich had suffered far worse, with 4000 houses damaged or destroyed, he said. The Lord Mayor, Alderman Clem Jones, said yesterday 13 750 Brisbane houses were affected by the floods. This figure would include houses that ranged from destruction to slight damage and houses that had water only under them.....The State Government had distributed almost $3 million for food, clothing, bedding and cooking utensils to alleviate immediate hardship. He said the area - by area totals of flood - ravaged houses remaining included: Ipswich 719, Ashgrove 164, Indooroopilly 18, Red Hill two, Taringa 116, Toowong 38, Torwood 309, South Brisbane 63, Fairfield 326, Oxley 231, Valley 162, Rocklea 148, Sherwood 139, Graceville 138, Chelmer 149, Waterford 11, and Woodridge seven.*

Although the Wivenhoe Dam (completed in 1985) is capable of significantly attenuating some events in the Brisbane River, widespread flooding across the lower reaches of the Brisbane River remains a real threat for at least 18 000 property owners in Brisbane during a 1% AEP event. Wivenhoe Dam has no mitigating effect on the Bremer River, acting only to control the downstream level of the Bremer River as it joins the Brisbane River.

In aggregate, South-East Queensland has more properties exposed to inundation from floods, with an average recurrence interval of 100 years, than any other area in Australia. This includes flooding in the Caboolture, Pine, Brisbane, Bremer, Logan, Pimpama, Coomera and Nerang Rivers and the major creeks. The total would be even greater if the properties exposed to flooding from urban storm water and the minor creeks were added.

CYCLONES

There is little doubt that tropical cyclones pose a significant threat to the urban communities of South-East Queensland. These spectacular storms are very large in scale, and have brought severe loss to the whole region. On long-term average, 1.2 cyclones pass within 500 km of Brisbane each year, whilst in the past 92 years at least fifteen of these storms have approached to within 100 km of down-town Brisbane.

There are three components of a tropical cyclone that combine to make up the total cyclone hazard - strong winds, intense rainfall and oceanographic effects including high energy waves, strong currents, storm surge and resulting storm tide.

Severe Wind: Tropical cyclones are accompanied by strong winds, with potentially destructive gusts (more than 130 km/h) within 100 km of the centre of Category 3 or greater storms. These strong winds can persist for hours, or even days, causing widespread building and infrastructure damage or even loss of life. Most of the structural damage caused by tropical cyclones is inflicted by the strong winds. This damage can be caused directly by the wind and/or by the debris that it propels, frequently with great force. The following extract from the *Telegraph* of 25 February 1893 illustrates the power of cyclone winds:

A recent visitor to Woody Point (Redcliffe) supplies the following account of the total destruction of Mrs. Bell's well known residence 'Klanger'. This place was caught in a tornado on February 17th (1893) at 7 a.m.

The first intimation the occupants had of the strength of the wind was the front door bursting open. Mrs. Bell, who was in bed at the time, went to shut the door, when she was lifted bodily up and her head knocked against the ceiling of the hall. Mrs. Bell was found amongst the debris, apparently without a broken bone but severely bruised.

Her daughter, Mrs. Hobbs, and the latter's two children, who were also in the house, had a miraculous escape from death, as the building fell in on them. In fact one child was under a wardrobe that took four persons to lift and the other had a hairpin knocked into her head. All of them were very much bruised, especially Mrs. Bell and her daughter.

The man servant was carried from the kitchen steps into a mulberry tree and hurt about the legs by falling timber.

The house and the 8 ft. 6 in. verandah appear to have been lifted bodily up, carried about five to ten yards and then crashed to pieces.

Nearly all the furniture is smashed to atoms and bedsteads are broken and twisted like so many twigs. At one time it was thought that a valuable piano, which had somehow escaped the weight of the falling building, was uninjured - but unfortunately that is not the case.

Perhaps the most remarkable incident is that a large box with a glass top containing birds eggs was not damaged in any way.

Parts of the galvanized iron roof were carried a long distance and wrapped around a big tree.

A light buggy belonging to Mr. Parry Okeden which was in a shed at the stable was lifted and carried into a fig tree. When taken down it appeared none the worse for its aerial flight, except that part of the ironwork was bent.

A poor horse, which had been feeding some distance away, must have been lifted up and dashed against a tree as the unfortunate animal was found almost cut in two.

Severe beach erosion at Palm Beach during 1967 *(Environmental Protection Agency photograph)*

Heavy Rainfall: Very heavy rainfall frequently accompanies tropical cyclones. Perhaps the most significant regional impact by a tropical cyclone in recent history was the severe and widespread flooding caused by tropical cyclone Wanda in January 1974 - the so-called 'Australia Day' floods that caused such devastation in Brisbane and elsewhere in the region. Flooding from the Brisbane River alone resulted in at least an estimated $200 million worth of damages at the time and at least 13 000 properties were affected. At least 30 houses were washed away and 15 people killed.

Severe Waves: One of the principal impacts of severe waves is significant beach erosion, especially when combined with storm tide effects. Between late January and early April 1967, a sequence of cyclones - tropical cyclones Dinah, Barbara, Elaine and Glenda - attacked the beaches of southern Queensland causing extensive erosion and economic loss to the tourist industry. This was followed in June by three east coast low ('winter cyclone') events which, together with the earlier cyclones, were estimated to have removed more than eight million cubic metres of sand from beaches between Point Danger and the Nerang River mouth. Extensive property damage occurred along the Gold Coast strip - houses fell into the sea at Mermaid Beach, Nobby's and Palm Beach. Large sections of the esplanade collapsed at Surfers Paradise, Main Beach and Palm Beach. A volunteer army of 5000 people placed around 100 000 sandbags along the foreshore helping to prevent many other houses being lost to the sea. It then took two years for natural accretion to rebuild much of the region's beaches.

Storm Tides: All tropical cyclones on or near the coast are capable of producing a storm surge, which can increase coastal water levels well above the normal high tide level. This leads to flooding by sea water in low lying coastal regions for periods of several hours and over as much as 100 km of coastline. Damaging storm tides have been experienced in South-East Queensland. In February 1954, for example, a severe cyclone that crossed the coast at Coolangatta created a surge in Moreton Bay that left boats in the tree tops at Beachmere. Waves at Kirra brought 2 m of water onto the highway, picking up cars. The *Courier Mail* of Monday 22 February 1954, for example, reported the effect of storm tide at McIntosh Island:

> *Twenty-two residents of McIntosh Island spent a nightmare eight hours before being rescued by police and lifesavers. At the first attempt ... three men made the island (by) boat and took the residents into the biggest of the houses. But soon after the stumps supporting the house gave way, and the party rushed outside seconds before the building collapsed. Drenched to the skin the party, which included six small children, then moved into another house on the highest point of the island. There, waist high in water, they waited for rescue. 'Then the wind dropped and we were able to make it. Five minutes after we had completed the rescue, the wind started howling again'.*

There have been only sixteen tropical cyclones come within 500 km of Brisbane since the 1974-75 season, about half the long-term average frequency. None has approached to as close as 100 km in that time. It is not surprising, therefore, that there is common view that the region does not have a cyclone problem.

EARTHQUAKES

Earthquakes occur when stresses in the Earth's crust exceed the rock's strength to resist, thus causing the sudden rupture of rocks and displacement along a surface called a fault. The fault may already have existed or may be newly created by the earthquake rupture. Energy from the fault rupture is transmitted as seismic waves that cause almost all damaging earthquake effects.

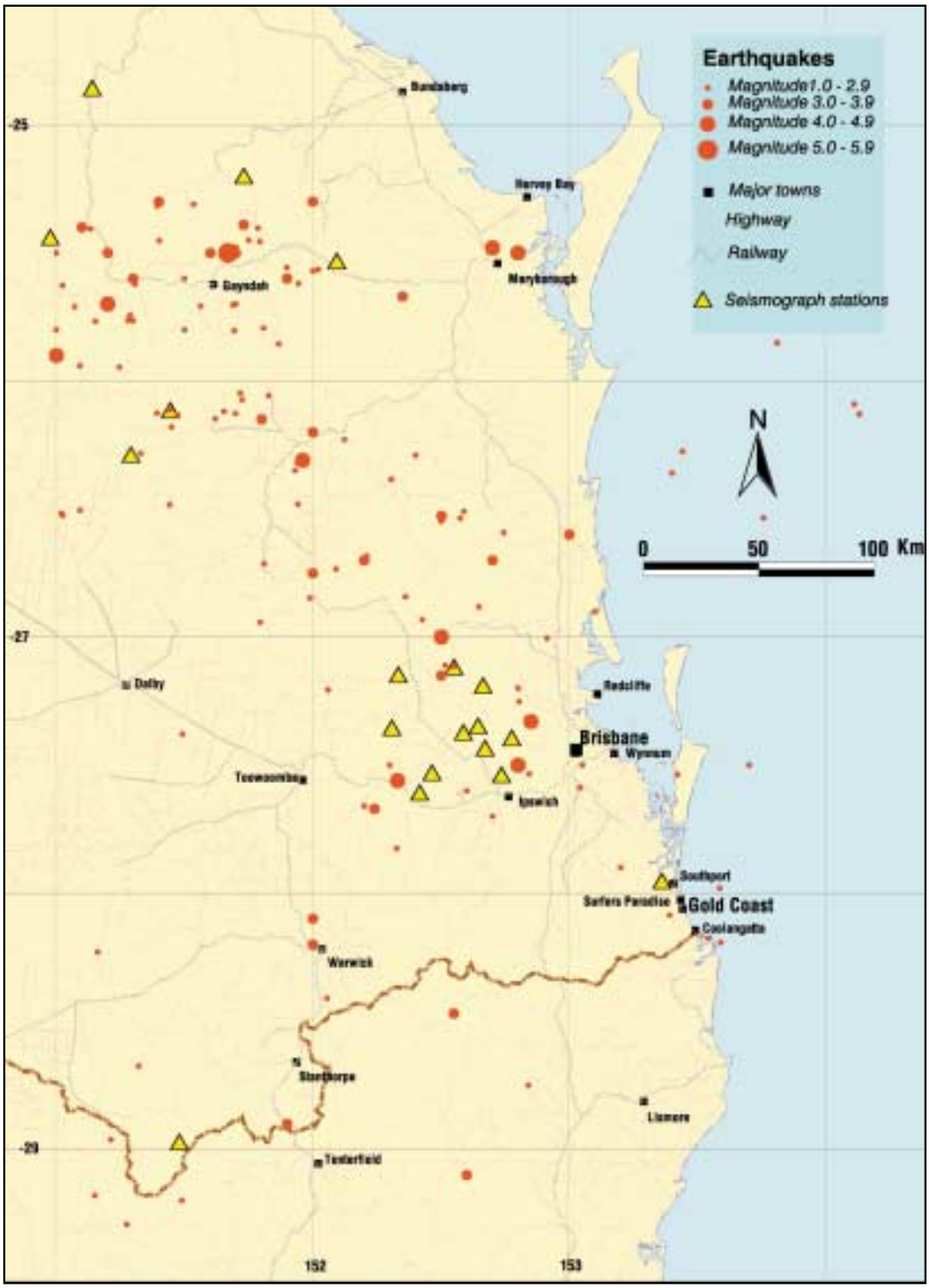
Although damaging earthquakes are relatively rare in Australia, the high impact of individual events on the community has made them a costly natural hazard, as witnessed by Australia's most lethal and costly earthquake - the Richter magnitude (ML) 5.6 event that struck Newcastle, NSW, on 28 December 1989. With increasing urbanisation and dependence on power, water, telecommunications and other lifelines, Australian communities are becoming more vulnerable to earthquakes.

There have been few reports of earthquakes causing significant damage in South-East Queensland. None-the-less, earthquakes large enough to cause damage have occurred in southern Queensland, most of them when population densities were much lower. The 1918 'Bundaberg' earthquake had a magnitude of 6.3 and is the largest recorded earthquake in eastern Australia. Its offshore location minimised damage but '[in Rockhampton] chimney stacks fell down, cracks appeared in buildings, windows were broken ... the event was widely felt in most suburbs in Brisbane ...' The earthquake was felt over a wide area of Queensland and northern NSW. Several significant earthquakes have also occurred near Gayndah over the last 120 years or so. Moderate magnitude earthquakes occurred there in 1883, 1910 and 1935, the latter causing minor damage. The 1935 earthquake was also felt over a wide area including South-East Queensland.

The earliest record of Queensland earthquakes are provided by the settlers and explorers John and James Green. Their diaries have recently come to light and the events they reported are yet to be corroborated. They provided a vivid account of an astonishing earthquake sequence on the shores of Lake Cootharaba, north of Noosa, where they were camped on the afternoon of 3 September 1862.

> *There was an eerie quietness over the land. The birds had fled. There was no movement of the leaves - not a ripple on the water. David I noted was ill at ease. He said the earth spirits were angry. A great roar sounded beneath our feet and the lands shook violently. Trees heaved upwards and downwards - falling in many directions. I fell upon the ground and could not move so violent was the ground shaking and sliding - one way, then the next. I could not stand no matter my effort. The horses cried out in fear as they fell upon each other trying to get upright and free all at the same time. It seemed an eternity before it ceased. There was a hush as we quietened the horses and secured them further so that they could not escape in their fear. I was fortunate to have placed the camp on high ground for the lake waters had risen considerably to a new shoreline on many feet and gained much depth of water....The great shaking came again and we were thrown to the ground as jolt after jolt came forth under the ground. Great waves rolled across the waters and crashed upon the new shores filling the waters with trash and debris. More shaking occurred soon after and again and again, until it was no more than rumbles in the ground.*

The Green brothers' extraordinary account indicates strong earthquake ground shaking corresponding to a seismic intensity of at least Modified Mercalli Intensity VII. Additional information may shed more light on the magnitudes of these intriguing earthquakes and any alterations they may have made to the landscape.



Historic earthquakes in the South-East Queensland region

LANDSLIDES

A landslide is the movement of a mass of rock, debris or earth down slope. Landslides can vary in size from a single boulder in a rock fall, to tens of millions of cubic metres of material in a debris avalanche. While not as well recognised in Australia as many other hazards such as cyclones, storm surge, floods and earthquakes, landslides cause significant economic loss as well as injury and loss of life.

While the Thredbo (NSW) landslide which killed 18 people in July 1997, or the Gracetown (WA) cliff collapse, which caused nine fatalities in September 1996, made the world news, many smaller events kill one or two people at a time, and do not receive such extensive media coverage. In Australia, a total of 90 people are known to have been killed by 39 landslides since 1842. An additional 118 people are known to have been injured. It is almost certain that these statistics are incomplete and that the number of fatal events is much higher than presently recorded.

Data are too incomplete to give accurate costs incurred from landslides but they have been estimated to total about $500 million since 1900. This may equate to billions, of present-day dollars. Landslides have caused many instances of damage and disruption to buildings, roads, railways, and pipelines. More than 200 buildings throughout Australia have been damaged or destroyed by landslide.

Certainly the most common trigger for landslides is an episode of intense rainfall. In South-East Queensland, intense rainfall events have in the past caused widespread landslide activity. This is especially so around the basalt capped ranges of Canungra-Beechmont, Numinbah, Tamborine, Springbrook Plateau, upper Tallebudgera and Currumbin valley areas. The rainfall event of 25-28 January 1974, associated with TC Wanda, produced about 1000 mm of rain over a three day period, a rainfall event with an annual recurrence interval of around 100 years. This rainfall gave rise to over 1800 landslides.

AGSO's Australian Landslide Database records a major landslide at Tallegalla Hill, Minden. The locality was about 11 km from Rosewood and 10 km from Marburg. It was reported in the *Sydney Morning Herald* of 18 March 1890 as follows:

> *A large hill...slipped bodily into a creek, by which it was surrounded with a roaring noise like that of an earthquake. Now where the hill stood is a sheet of water and five or six farms are not recognisable, the high land being now low and vice versa.*

Road destroyed by landslide following a heavy rainfall event

On the following day the *Sydney Morning Herald* noted that at least 323 700 sq m had bodily shifted, sometimes to a depth of 12 m, and that entire farms were ruined and houses destroyed. If a mean depth of 6 m is assumed, then the volume of this landslide is estimated to be almost 2 million cubic metres. It was probably triggered by the tropical cyclone that crossed the south Queensland coast on 11 March 1890. This cyclone also caused flooding in the Brisbane River. The landslide may have been a debris flow.

Fortunately, landsliding from events such as the 1890 and 1974 cyclones had minimal impact upon communities. Disasters like the Thredbo landslide, however, should serve to remind us that the risks are ever-present, especially given that future development of urban, rural and semi-rural areas will continue to intensify already burgeoning slope stability problems.

Landslides from cliffs can happen spontaneously or as a result of human activity. On several occasions in Australia people have been injured or killed by a single rock. Also, in the past four years, five children in Queensland have been temporarily buried as a result of three separate instances of tunnelling into sand cliffs. If people had not been present to rescue them quickly, these incidents could have resulted in fatalities.

The only recorded landslide death in the study area happened on 2 September 1936 on North Stradbroke Island. The *Sydney Morning Herald* of 3 September 1936 reported the following:

> *When a cliff, 20 feet high, on the main beach headland at Amity Point, suddenly collapsed this morning (two children),.... playing at the foot, were buried under several tons of sand.*
>
> *The girl was rescued uninjured, but prolonged efforts to resuscitate the boy were unavailing.*
>
> *With a number of other children, the boy and girl were playing on the beach, tunnelling into the bank.....Rescuers were hampered by further falls, and they did not know exactly where the children were buried. It was not until the girl had been uncovered that they had any idea where her brother had been standing.*

SEVERE STORMS

South-East Queensland is a region particularly susceptible to severe thunderstorms during the summer months with their hail, flash flooding, lightning and strong winds. These events are responsible for most of the annual damage to property from natural hazards in the region. There are about 20 days a year on which severe thunderstorms develop and on many occasions there have been up to five individual storm systems involved on any one day. Not all thunderstorms, however, produce damage. Over the past 45 years the region has experienced, on average, two damaging thunderstorms each year. In both 1995 and 1999 there were eight such storms.

Destructive winds from thunderstorms occur much more frequently in the South-East Queensland region than do the severe winds brought by tropical cyclones or east coast lows. Thunderstorm winds do, however, impact over much smaller areas. As a result, thunderstorms tend to cause localised but sometimes severe damage in a few suburbs, rather than affecting the whole region. Track widths typically vary from 1 km upwards and can extend for over 100 km if conditions are 'favourable'. Approximately 30% of all severe thunderstorms produce damaging hail. These swaths of hail may impact areas a few kilometres in width and up to 10 km in length. Thunderstorms can also bring with them flash flooding.

During a severe 'supercell' thunderstorm in January 1985, the peak wind gust at Brisbane airport was 184 km/h and was accompanied by 60 mm diameter (tennis ball-size) hail. This event devastated several northern suburbs, with many houses unroofed and with many windows broken and cars pockmarked by hail. In 1995 reliable reports were made of hail up to 120 mm (rockmelon size), in one instance penetrating the tiled roof and ceiling of a house before destroying a coffee table inside! A similar Sydney storm in April 1999, affected 22 000 properties and caused an Australian record $1.7 billion in insurance losses, a clear indication of the enormous damage potential of such storm systems in densely-built metropolitan regions.

A tornado during the Bucca storm in November 1992

Examples of hail from the November 1995 storm which damaged the roofs of more than 300 homes in the western Brisbane suburb of Bellbowrie

Tornado damage from the November 1973 event in Brisbane

Almost all storms produce some lightning and associated thunder. An average thunderstorm produces a few lightning flashes each minute and generates several hundred megawatts of electrical power during its lifetime. Each year in Australia, lightning claims up to ten lives and causes over one hundred injuries.

Tornadoes may accompany severe supercell thunderstorms. On average they occur about one day per year in this region. Peak wind speeds are estimated to approach 450 km/h in the largest tornadoes. Contrary to popular belief, Australian tornadoes can be just as destructive as their US counterparts. There have been at least 15 confirmed or suspected tornadoes in the region over the past 45 years. In November 1973 a tornado, between 100 m to 230 m wide, cut a 51 km swath of damage from Brookfield through Nathan to Eight Mile Plains and across Redland Bay. It unroofed 500 houses, damaged around 1400, some 500 of which were declared structurally unsafe. The impact of a re-occurrence of such a storm with the present extent of suburban development would be increased many times over.

EAST COAST LOWS

East coast lows, also known as east coast cyclones, winter cyclones or easterly trough lows, are one of a family of low pressure systems which most often develop during the winter months along the east coast of Australia south of 25ºS (about the latitude of Bundaberg). These large scale storm systems often develop rapidly and can become quite intense, with storm force winds extending over wide areas. These events contribute significantly to flooding and wind damage along the coastal margins as well as marine accidents, storm surge and beach erosion.

Whilst they share many features with tropical cyclones, east coast lows tend to intensify much more rapidly and form much closer to the South-East Queensland region, with the result that warnings of severe weather are typically quite short. The incidence of this type of storm fluctuates quite widely from one year to the next, with none in some years and the highest incidence being twelve in 1978/79. The long term average annual occurrence is about 2.5 storms per year but since 1960 the average has increased to 3.7.

The effect of these storms on nearby coastal areas can be severe, frequently with loss of life and property from flooding and maritime incidents. The first documented east coast low in Queensland occurred in August 1846 when the vessel Coolangatta was driven ashore in the area now bearing its name. The 1600 tonne Cherry Venture, one of the more notable shipwrecks in recent history, was driven ashore south of Double Island Point - a victim of the severe July 1973 east coast low. Bureau of Meteorology estimates indicate approximately 35 deaths in the region can be attributable to east coast lows over the period 1973 to 1999, the majority being due to flooding.

HEAT WAVES

Heat waves kill more people in Australia than any other natural hazard. In the period between 1803 and 1992 at least 4287 people died as a direct result of heat waves, almost twice the number of fatalities attributed to either tropical cyclones or floods over much the same time-frame (Coates, 1998). As with most of the hazards dealt with in this study, there appears to be a significant lack of community awareness of the risks associated with heat wave, even though the region experiences such events, on average, about once every five years. It is clearly a widely overlooked, even unknown, killer.

The records of fatalities caused directly or indirectly by heat wave are, at best, fragmentary for South-East Queensland. They have, none-the-less, been recorded in the region since at least 1899. Perhaps the most severe heat wave experienced here, in terms of fatalities, occurred in late January 1940, when at least 80 people died (51 males and 29 females).

The dominance of males in the lists of heat wave fatalities at that time can be explained by the predominance of heavy manual labour in the out-doors. In more recent times, elderly females tend to be the most at risk. Between 19 and 21 January 2000, for example, a heat wave reportedly killed 22 people in the region. The victims died of heat associated stress, with most of the victims being elderly women living alone and closed away inside their homes for ‘security’.

There are, however, various Workplace Health and Safety requirements in place aimed at protecting workers and school children from the stress of high temperatures in the workplace, school and so on. The general public, in particular elderly women who tend to close themselves up inside their home in the suburbs, do not have the same degree of oversight or protection.

BUSHFIRES

Whilst bushfires in South-East Queensland have seldom been as severe as the worst fires that have occurred in the southern states (such as the 'Ash Wednesday' fires that claimed 75 lives in South Australia and Victoria in 1983), serious fires have occurred in the region during most months of the year. The increasing popularity of rural residential living and the preservation of natural areas within urban developments brings with it an increasing level of risk.

The most notable events in recent years were the fires of September and November 1994 which burnt through more than 4800 ha of exotic pine plantation and destroyed both rural and urban property on the Sunshine Coast and in Caboolture, Pine Rivers, Brisbane and other local government areas. These fires also injured nine fire fighters, seven very seriously. More recently, some 2000 fires (90% of them deliberately lit) were reported throughout the region over a three week period in August-September 2000. It is clear, however, that they are not just a recent phenomenon. For example, according to extracts from the records of the Caboolture Divisional Board, in 1883 a Mr. Walsh of Humpy Bong (i.e. Redcliffe) threatened to 'expose' the Board through the press, complaining of the danger of trees falling across the road due to bushfires, one tree having already fallen on his horses.

The bushfire season for South-East Queensland typically extends from mid to late winter through to early summer. The greatest danger occurs in the period towards the end of winter and into spring, especially if a good summer 'wet' season, which produced abundant growth of grass and other fuel, is followed by a winter of low rainfall and lengthy periods of dry westerly winds. On average, the region experiences a serious fire season about once every five years. The vast majority of bushfires are started either by human carelessness or are deliberately lit.

There is perhaps a perception that only buildings in rural areas are at risk from bushfires. There is little doubt that rural buildings are most at risk, however, buildings in urban areas within 100 m of the bush interface are also subject to high levels of risk. The Bribie Island fire of November 1994 should serve as a clear reminder of how serious the bushfire threat can be to urban development. Those fires, which burnt mainly through wallum bushland, were so intense that they left behind only bare sand and white ash. Fortunately only a few sheds and fences were destroyed and only limited damage was done to a few houses and gardens on the bush interface - but it could have been a lot worse.

Bushfire damage on Bribie Island, November 1994 *(Photo: Caboolture Shire Council local studies collection)*

Although the key risk is to buildings, people are also at significant risk, especially if they are caught in the open or in vehicles that are inadequately protected. When considering the risk to people, fire fighters should not be overlooked. This risk was highlighted recently by the deaths of several firefighters in other states and the serious injuries suffered by nine volunteer firefighters near Beerwah (the so-called 'Bell's Creek fire') in November 1994.

LOOKING AHEAD

It is clear that the region has a long and tragic history of natural disasters from a wide range of hazards, but what about the future? Can we expect the region to suffer the impact of damaging cyclones, floods, earthquakes, landslides and bushfires in the years ahead? Yes, ***you can stake your life on it***!

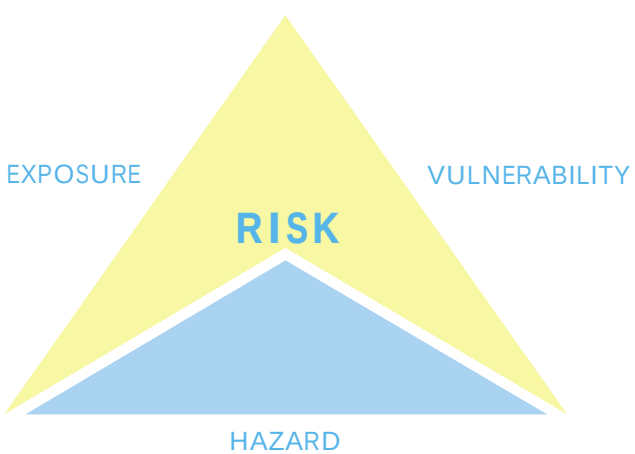
The past quarter of a century has been relatively 'quiet' as far as disasters in the region are concerned. Over the same period, however, the region has witnessed very significant growth in population and economic development. Even without taking such things as climate change and its likely effects on sea level, cyclone numbers and rainfall intensity into account, the potential risk continues to grow. That means that the next severe cyclone that comes down the coast, for example, will have more people, houses, businesses and infrastructure to impact on.

WHAT IS RISK?

In the context of this report, 'risk' can be defined as:

> *the expected number of lives lost, persons injured, damage to property and disruption of economic activity due to a particular natural phenomenon.*

Risk can thus be seen as the interaction between a hazard phenomenon, the things that are exposed to that hazard, such as people, houses and so on, and the degree to which those things are more or less vulnerable to the impact. The level of risk varies depending on three factors - hazard, exposure and vulnerability. This can be illustrated by assuming the 'dimension' of each of those three factors represents the side of a triangle, with risk represented by the area of the triangle. In the figure, the larger (yellow) triangle portrays each of the variables as being equal, whilst in the smaller (blue) triangle the risk has been reduced by halving both exposure and vulnerability. The reduction of any one of the three factors to zero would consequently eliminate the risk.



Unfortunately there is little than can be done to reduce the hazard component (other than reducing the fuel for bushfires), so any effort to reduce risk must be directed towards reducing either the level of exposure or the vulnerability of the things that are at risk.

To assess community vulnerability we have adopted a systematic approach to describing the elements at risk in the community and their vulnerability to hazard impact and group these into the five themes of setting, shelter, sustenance, security and society (the 'five esses'). These themes include:

- ***Setting:*** the physical environment (climate, vegetation, geology, soils, land use, topography, elevation, etc.), administrative arrangements, and population and its distribution.
- ***Shelter:*** The buildings that provide shelter to the community at home, at work and during recreation.
- ***Sustenance:*** Utility and service infrastructures such as water supply, sewerage, power supply and telecommunications.
- ***Security:*** The availability of facilities such as hospitals, nursing homes, industries, commercial premises, agricultural land use, ambulance stations, fire stations, police stations and works such as flood retention basins and levees.
- ***Society:*** This includes the more intangible measures such as language, ethnicity, religion, nationality, community and welfare groups, education, awareness, meeting places, cultural activities and so on.

These data provide a detailed quantitative description of specific aspects of the regions risk environment and allows us to identify those districts that provide a disproportionate contribution to community risk because of the number and nature of the elements they contain.

IS SOUTH-EAST QUEENSLAND A RISKY PLACE?

The South-East Queensland study area has 53% of the Queensland total population and an even greater proportion of its commercial and infrastructure development is concentrated in the study area. Therefore, it seems reasonable to assume that South-East Queensland represents a major proportion of the State's risk exposure. Indeed, our analysis enables us to make the following judgements regarding the 'riskiness' of South-East Queensland.

- The aggregate potential losses across the study area from riverine flooding at the 100 year average recurrence interval (ARI) flood event level represents the highest aggregate urban flood risk in Australia, with as many as 25 650 developed properties likely to experience overfloor inundation. This compares with 1760 properties in the Hawkesbury-Nepean catchment of NSW for the same ARI flood. Given the size of the region and the number of catchments involved, however, it is unlikely that a single rainfall event would result in a 100 year ARI flood event in each river, though a single rainfall event (e.g. resulting from a cyclone) could cause all of the rivers in the region to flood.
- the risk posed by tropical cyclone severe wind is low to moderate across most of the region. There are, undoubtedly, localised areas in which the combination of building age, construction and site conditions could produce high damage levels. The amount of damage likely to occur as a result of a design level event (1000 ARI) wind would equate to the total damage to about 1500 dwellings;

- the risk posed by earthquakes is low to moderate across most of the region. As with cyclone winds, there are, undoubtedly, localised areas in which the combination of building age, construction and site conditions could produce high damage levels. The amount of damage likely to occur in a design level event (500 year ARI) earthquake would equate to the total damage to about 2000 buildings;
- across the region as a whole there is a low risk from storm tide inundation, however, the aggregate potential at the 100 year ARI level represents the highest such aggregate risk in Australia, with as many as 9550 properties likely to experience overfloor inundation (by contrast, Cairns has 3800 buildings and Mackay 2170 buildings likely to have overfloor inundation from a 100 year storm tide event). It is emphasised that, in South-East Queensland, it would be unlikely that this aggregate number would be reached as the result of a single cyclone;
- urban stormwater and flash flooding caused by cyclones, east coast lows or severe storms pose a significant threat of both fatalities and economic loss in localised areas. We have not, however, quantified the level of that risk;
- there is a significant risk of hail, lightning and wind from severe thunderstorms, though the impact from any one storm will be very localised. We have not, however, quantified the level of that risk;
- there is a significant and widespread risk of fatalities from heatwaves, the level of which, however, has not been quantified at this stage;
- across the region there is a low risk from landslides. In a few areas of steep country, however, the localised risk is significant, and will be more significant with increasing pressure from urbanisation;
- there is a low overall risk of bushfire damage in urban areas. However, the exposure in rural areas and rural fringe areas is significant.

Major floods, storm tides and storms all hold the potential to cause significant economic harm and kill people. The warning systems and other mitigation strategies already in place in the region, however, should help to minimise both loss of life and economic harm if the warnings issued are acted upon in an appropriate and timely manner. For this to be achieved, however, the community must be aware of the risks they face and understand the warnings and their significance to them.

Reducing exposure: The most direct way of reducing exposure is to ensure that houses and other buildings are not developed in areas known to be frequently affected by hazards, such as in the low-lying parts of river floodplains or on steep, landslide-prone slopes. In Queensland, local governments implement such planning regulations. They establish and enforce planning constraints that are specifically aimed at controlling development in areas that would, for example, be inundated by a flood or storm tide with an average recurrence interval of 100 years, or ensuring that development platforms are constructed to the designated design event for the specific land use.

Another approach to reducing exposure is to engineer defences such as levees and flood retention capacity in dams. Such efforts are generally quite expensive and can, in fact, give rise to an urban myth that they have eliminated the risk entirely, when in fact they have only been designed to reduce or eliminate the more frequently occurring levels of inundation, such as the flood that occurs on average once in ten or twenty years. There is, for example, a widely held view that the completion of Wivenhoe Dam in 1985 means that there will never be a repetition of the 1974 floods. This is clearly not the case, given that there are limits to the flood retention capacity of the dam and the fact that it can only influence the flood level in the Brisbane River itself. It only has limited influence on floods that originate in the Bremer River (the southern half of the Brisbane catchment), or in the downstream water courses such as Oxley, Enoggera or Bulimba Creeks. However, the Hinze Dam, constructed in the mid 1970's and raised in 1987-1989, has provided a significant reduction in flood risk in the Nerang River catchment. To reduce flood risk still further, local Councils are currently investigating additional mitigation measures.

Given that development has been going on in some parts of the region for more than 150 years, development has sometimes preceeded before a good understanding of the nature of natural hazards had been reached. Where people are living in areas known to be at risk, the usual approach to reducing their exposure is by providing warning of an approaching hazard, such as a flood, so that they can move their possessions and themselves to higher ground. For all of the hazards that have an atmospheric component (cyclones, floods, storms, etc) such warnings are provided by the Bureau of Meteorology.

Reducing vulnerability: Amongst disaster managers in particular it is recognised that 'an aware community is a prepared community'. Being aware of the local hazards, and the risks they pose, is one of the most potent ways to reduce the vulnerability of an individual, a family or a community. It is one thing for the Bureau of Meteorology to produce an accurate forecast and warning of an impending flood; it is another thing, however, for members of the community to interpret how it may impact on them and their situation and what appropriate action they should take. For example, a flood warning normally is expressed in terms of a depth of water measured on a local flood gauge. What that forecast flood height means in terms of where the water will reach on an individual's property, however, is unclear, unless that individual has enquired from the local council about their exposure. Armed with the information from the warning and its interpretation to their own locality, individuals or households can then make better decisions about how to reduce their vulnerability.

There are practical action guides for all of the hazards described in this report which have been prepared by Emergency Management Australia. These have been developed in close consultation with agencies such as AGSO – Geoscience Australia and the Bureau of Meteorology and are based on the experience of disaster managers across Australia over many years. Copies are freely available from councils, the local SES unit or from the Department of Emergency Services. Even the local telephone book has useful information and safety tips and your insurance company will also have an understanding of the key risks in your area. Simply by being aware and understanding what to do when disaster strikes reduces ones vulnerability.

Armed with an understanding of what hazards can impact on the community and information on how to cope with their impact, people can develop their own 'disaster plans'. A family or household disaster action plan might include activities such as:

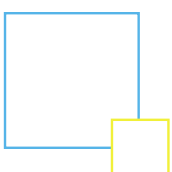
- keeping the yard free of loose material in the lead up to the summer storm season;
- storing precious family photos and documents at a safer locality;
- stocking up on emergency supplies such as LP gas, batteries, canned foods, long life milk and candles, as well as topping the car up with fuel when a flood or cyclone warning is issued. Even if the hazard does not impact directly on you, it will almost certainly disrupt normal services such as power supply and the distribution of food to local outlets for a time;
- learning basic first aid skills and maintaining an adequate first aid kit;
- keeping in touch with neighbours and making sure that they are aware of any warnings, especially if they are elderly and living alone;
- if you believe that you may need to be evacuated in a flood or storm tide event, make arrangements to move in with friends or relatives in areas free of inundation. This will make the process less traumatic for you and also reduce the load on public shelters and evacuation centres. Include your pets in your evacuation plans; and,
- listen to the radio for updates of warnings and advice from emergency managers.

Any or all of those actions will reduce the vulnerability of both you and your family, as well as your neighbours and the wider community.

There are, of course, steps that are taken, through engineering design and the materials used, to reduce the vulnerability of buildings and utilities such as the power supply. For many years the Queensland Building Act, and relevant Australian Standards to which it refers, have provided engineering standards for the construction of buildings in areas subject to high winds and earthquake ground shaking. Similar standards are being developed for building in landslide, flood or bushfire-prone areas.

The Queensland Building Act first came into force for domestic buildings (for strong wind) in 1982, so any house built after that time should be strong enough to survive all but the strongest winds. Older houses will also be quite strong, however, there are now guidelines available to strengthen older buildings to modern wind and earthquake standards. The Newcastle earthquake showed that older solid brick houses or houses with brick chimneys, for example, are more likely to suffer damage than are modern brick veneer houses. Your local council's building department can give you advice regarding what might need to be done.

It is a sad fact that most fatalities in natural disasters in South-East Queensland are caused by inappropriate behaviour. People are killed every year because they can't resist doing things such as lighting fires on hot and windy days, driving across fast-flowing flooded streams, 'surfing' in storm waters, or taking a small boat out on Moreton Bay or The Broadwater in spite of warnings of high winds and seas.



MORE INFORMATION

More information about the hazards that can be experienced in South-East Queensland and the risks that they pose are contained in the detailed report Natural Hazards and the Risks They Pose to South-East Queensland, published by AGSO on CD (see the AGSO web site at www.agso.gov.au for details). Other information, including up to date severe weather warnings and advices can be found on the Bureau of Meteorology web site at www.bom.gov.au. Telephone: (02) 9662 2182.

Information on how to prepare for disasters and how to reduce you exposure and vulnerability can be obtained from your local council. Other web sites that are useful include:

Emergency Management Australia

www.ema.gov.au

Telephone: (02) 6266 5402

Department of Emergency Services

www.emergency.qld.gov.au