

CHAPTER 12: A MULTI-HAZARD RISK ASSESSMENT

Ken Granger and Trevor Jones

Overview

On a global scale, Australia, as a whole, is a very safe place. 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 over 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 24 years of this 34 year period Queensland has been relatively free of major cyclone and flood disasters.

The risks posed by natural hazards in the region are clearly significant, though perhaps not as widely recognised as they deserve to be given the region's disaster history. A multi-hazard risk assessment is, therefore, clearly required.

Our approach in developing this multi-hazard risk assessment of South-East Queensland has been consistent with the general risk management process outlined in *AS/NZS 4360:1999 Risk management* (see Figure 1.1) and its evolving application in the emergency (or disaster) risk management field. So far in this report we have:

- established the risk study context and process;
- identified the key risks faced by the South-East Queensland community that are posed by a range of natural hazards; and,
- analysed and characterised those risks.

In this chapter we evaluate these risks and prioritise their significance to the South-East Queensland community.

Risk Evaluation and Prioritisation

Several methodologies have been described in the literature for evaluating and prioritising risk as the first step towards establishing treatment priorities and strategies. The method that has gained wide recognition amongst Australian emergency managers is the 'SMAUG' approach based on the work of Kepler and Tregoe (1981). In this instance, SMAUG is not J.R.R. Tolkien's dreaded dragon, but an acronym standing for:

Seriousness, Manageability, Acceptability, Urgency and Growth

The method involves rating each risk in relation to these criteria as being high, medium or low (see, for example, the discussion of this approach in Salter, 1997). The risk management standard (*AS/NZS 4360:1999*) provides a similar approach based on a matrix to rate risk likelihood qualitatively against its consequences (see Standards Australia, 1999, Appendix D).

Although both of these approaches provide a useful method for reaching a qualitative (and subjective) evaluation of risk, especially for a single hazard impact on a relatively small community, they are significantly less useful when applied to a multi-hazard risk evaluation and prioritisation for very large and complex communities such as that covered in this study. The quantitatively-based total risk approach that we have adopted in this study provides a more objective means of identifying the risks

that pose the greatest threat to the South-East Queensland community and to its constituent neighbourhoods. To achieve this we have measured the input of the three key variables in the total risk relationship described in Chapter 1 – namely the hazards, the community elements exposed to those hazards and the relative vulnerability of those elements.

Risks compared: Although there is still some way to go before we can produce a single statistic that is able to measure total risk across all hazards, we have been able to produce statistics that do provide a comparison of the community's exposure to some major hazards.

Building damage is the single, best indicator of risk. That is, the level of building damage can be used to rank risks from various natural hazards (when considered against its probability of occurrence). Building damage can also be used to estimate risk in absolute terms, although such estimates will be incomplete. Other potential direct and indirect costs to the community, for example from casualties or from business interruption, are also important sources of risk. However, the damage to buildings may be the largest component of direct damage from natural hazard disasters (Bureau of Transport Economics, 2001).

Average annual damage or average annual cost figures are commonly used in the insurance industry and other areas with an interest in the cost of disasters. The BTE study, for example, shows that Queensland's average annual cost of natural disasters over the 1967 to 1999 time frame was \$239 million, of which 46.7% was contributed by floods, 37.5% by cyclones and 15.6% by severe storms. There were no damaging earthquakes in Queensland during the time frame. However, the proportion of the NSW average annual damage bill of \$484.1 million contributed by the Newcastle earthquake is 29.1%, compared with 26.5% for flood, 40.0% for severe storm and 3% for bushfires.

The use of building damage as a surrogate indicator for exposure across all elements at risk clearly imposes limits. However, it is clear that in Australian urban areas, damage to buildings has been the largest component of both direct and indirect damage in natural disasters. The contribution of building damage to the total estimated costs in four Australian natural disasters are shown in Table 12.1.

Table 12.1 Contribution of building damage to costs associated with four disasters (based on data from Tables 5.1, 5.2, 5.3 & 5.5 in BTE, 2001)

	Lismore flood 1974	Cyclone <i>Tracy</i> 1974	Ash Wednesday bushfires 1983	Nyngan flood 1990
% of direct costs	49	91	61	72
% of indirect costs	26	71	32	45
% of total costs	44	88	59	65

The estimated intangible costs (e.g. from fatalities and injuries to people) have been excluded from the totals.

A comparison of estimated residential building damage from earthquakes and from severe winds from tropical cyclones, for the entire South-East Queensland region, is shown in Figure 12.1. For earthquakes, damage losses are defined in terms of the percentage of the repair or replacement cost of a 'typical' residence including contents or, alternatively, the percentage loss of the repair or replacement cost of the entire residential building stock and contents. For cyclonic winds, damage losses are expressed as a percentage of the total insured value of a 'typical' residential building and its contents. Alternatively, the damage losses for wind can be considered as a percentage of the total insured value of all of the residential buildings and their contents.

The damage losses are the minimum losses expected for the probability associated with that loss. For example, for earthquakes, there is an annual probability of 0.5% that damage losses will be at least 0.007% of the total insured value.

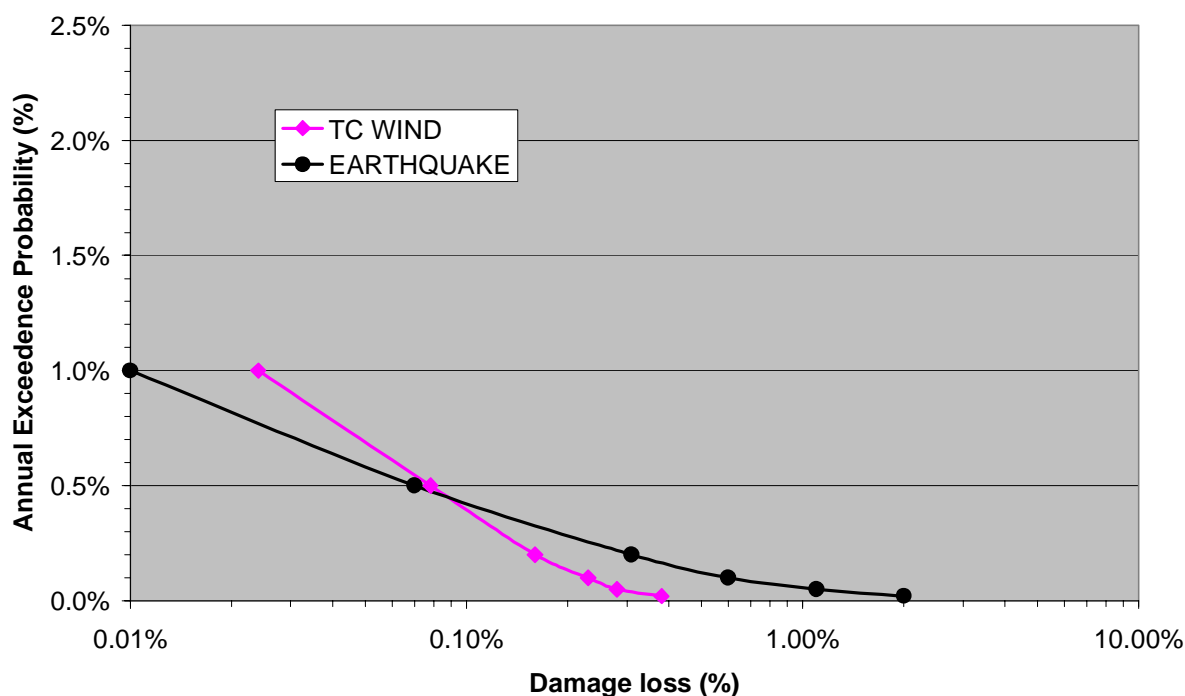


Figure 12.1 Comparison of percent building and contents damage from earthquake and cyclone wind

The uncertainties in the results are not shown in Figure 12.1. Because of the very large uncertainties, the risks posed by earthquakes and by severe winds from tropical cyclones, as determined from residential building damage alone, cannot be distinguished apart in Figure 12.1. Risk is related to the area underneath the curve. An important feature of the risk from tropical cyclone winds, and especially from earthquakes, is that a significant amount of all the risk from these hazards is attributed to extreme events. That is, relatively frequent events will not cause high levels of damage, particularly from earthquakes. However, very rare events have the potential to cause large amounts of damage (and earthquakes apparently more than cyclonic winds).

The risks posed by storm tide inundation and flooding are also compared. Structure and contents loss curves for flood damage (Blong, 2001) are used to estimate the percent damage loss. The impact of storm tide inundation compared to flood inundation when determining damage estimates is unclear. It is considered, however, that salt water will inflict greater damage and this has been incorporated in the storm tide damage loss shown in Figure 12.2. Though no modelling was available for riverine flood with AEPs less than 1%, damage from riverine flood significantly exceeds damage from storm surge inundation for AEPs of 2% and 1% (Figure 12.2).

Although Figures 12.1 and 12.2 are both based on percent damage loss they are not directly comparable. Earthquake and tropical cyclone wind damage losses are based on aggregated damage estimates from numerous scenario events randomly imposed on areas within the region, whereas storm tide and flood damage estimates are based on inundation levels with a particular AEP imposed over the entire region. It is considered that although the latter estimates will overestimate regional risk, they represent the numbers that disaster managers need to base their plans, especially for carrying out precautionary evacuations.

Clearly, the estimates of damage in the figures contain many limitations and uncertainties, and the comparisons of risk must be taken as indicative. We refer the reader to the individual hazard chapters for discussions of some of the limitations and uncertainties.

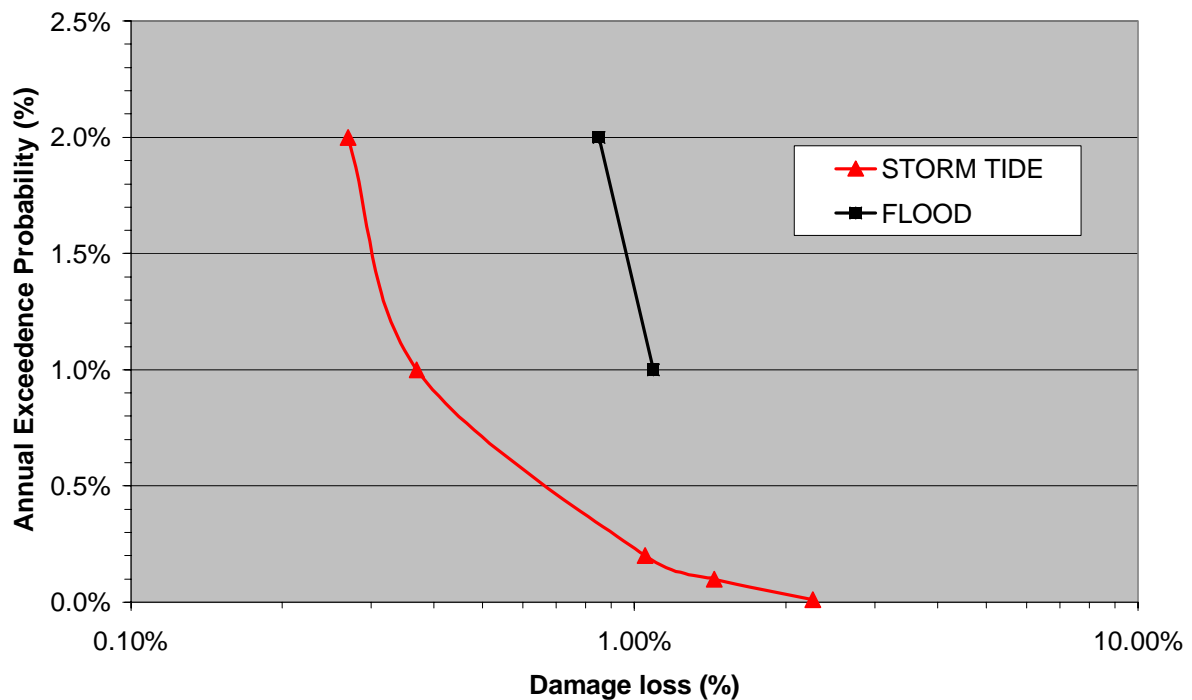


Figure 12.2 Comparison of percent building and contents damage from storm tide inundation and flood

Risk Thresholds

It is difficult, if not impossible, to be categorical about levels of acceptable or tolerable risk. Such risk criteria vary greatly over time, from circumstance to circumstance and from the different perspectives of each individual member of the community. For example, many people will tolerate the minor levels of flooding that might occur once every five or so years, especially if it affects few properties. The community generally will be less tolerant of moderate to major flooding that causes widespread dislocation and damage. Major levels of inundation or wind damage that kill people and produce massive economic loss are typically 'unacceptable'. Whilst this seems to be an eminently reasonable approach, it can also be viewed as being unrealistic, especially where the event that creates tragic losses is very rare.

It is relatively easy and inexpensive to control, or even eliminate, the nuisance levels of flooding that most people tend to tolerate. It is, however, economically impractical, if not physically impossible, to eliminate the risk of rare but catastrophic levels of riverine or storm tide inundation. Similarly, it would be prohibitively expensive to build structures to withstand the impact of the largest likely earthquake or the strongest likely wind. There is an inverse relationship between risk acceptability and risk controllability. The widely adopted response to this paradox is to establish thresholds of risk that are economically viable to implement and socially acceptable. Events that exceed those thresholds are coped with, if, and when they occur. In South-East Queensland the following thresholds, based on local government planning thresholds or Australian Standards, are either explicitly or implicitly accepted, probably with minimal community input:

- for destructive winds - under the criteria established in *AS 1170.2-1989*, no building should fail unless exposed to wind loads greater than those for which there is a 5% probability of exceedence in any 50 year period (i.e. an ARI of around 1000 years);

- for storm tide – varies between LGA with coastal exposure but generally those LGA require ground fill levels of new urban subdivision development to be above the level of the 100 year ARI storm tide event (plus allowance for other factors), and new building floor levels to lie above the level of the 100 year ARI storm tide plus 0.3 m;
- for flood – again these vary between the various LGA, however, most require ground fill levels of new urban subdivision development to be above the level of the 100 year ARI flood, and new building floor levels to lie above the level of the 100 year ARI flood plus 0.3 m;
- for earthquake - the criteria established in *AS1170.4-1993* are the minima to prevent buildings suffering structural collapse under earthquake loads for which there is a 10% probability of exceedence in any 50 year period (i.e. an ARI of around 500 years). More stringent design standards are required for structures used for what we have termed ‘critical facilities’.

This approach would seem to set inconsistent standards of ‘risk acceptance’ and is certainly not unique to South-East Queensland. The thresholds for earthquake and severe wind have largely been set by agencies outside South-East Queensland, especially those involved in establishing the various standards for structures under the Australian Building Code. For hazards for which no Australian standards exist (flood and storm tide), local government planning guidelines play a larger part in setting thresholds.

These thresholds do not generally address the risks to structures (and consequently people) built before their introduction. The vulnerability of older structures to earthquake loads, for example, has, as a result of the losses experienced in the 1989 earthquake in Newcastle, been addressed through the publication of *AS 3826-1998 Strengthening existing buildings for earthquake* (Standards Australia, 1998). A similar engineering guideline (rather than a standard) for upgrading older houses in high wind areas has also been published for both non-cyclone areas (Standards Australia and ICA, 1999a) and cyclone areas (Standards Australia and ICA, 1999b). These documents, which provide guidance relating to the improvement of older buildings, are not mandatory in their application. No equivalent document exists for storm tide or flood.

Is South-East Queensland a Risky Place?

The numbers published in the BTE study do not permit a breakdown below the state level, however, given that 53% of the State’s total population and an even greater proportion of its commercial and infrastructure development is concentrated in the study area, it seems reasonable to assume that it represents a major source of the State’s risk exposure. Indeed, our analysis enables us to make the following judgements regarding the ‘riskiness’ of South-East Queensland **at threshold levels**:

Flood: It is clear from this analysis that river and creek flooding represents the greatest regional risk overall. Furthermore, the aggregate potential losses across the study area from river flooding at the 1% AEP level represents the highest aggregate urban flood risk in Australia. Flooding across the region affects at least 47 400 developed properties during an event with a 1% AEP (100 year ARI), with many more properties being completely isolated by the floodwaters. Of this number, more than half of the buildings are affected by overfloor flooding. This compares with 1760 properties with overfloor flooding in the Hawkesbury-Nepean catchment of NSW for the same AEP level of flooding (Smith 1991).

Damage (as a percent of sum insured) per building across the entire study area is about 1.1% per building (including contents) during a 1% AEP event, with more than half of the damage falling within the Brisbane-Bremer catchment. About 27% of the damage falls within the Pimpama-Coomera-Nerang-Tallabudgera-Currumbin catchment, 13% in the Logan-Albert and 2% in the Caboolture-Burpengary catchment (flood damage for Pine Rivers could not be calculated because of the lack of a

suitable DEM from which to model flood depths). The areas with the greatest damage (e.g. Fairfield, Rocklea, Chelmer, Saint Lucia, Toowong and Graceville) are areas which suffered substantially in the floods of January 1974.

Storm Tide: Across the region as a whole there is a low risk from storm tide inundation, however, the aggregate potential at the 1% AEP level represents the highest such aggregate risk in Australia. There are 9550 developed properties across the region that would be exposed to overfloor inundation in a 1.0% AEP (100 year ARI) storm tide event. This represents about 1.5% of all developed properties exposed at the ‘design’ level event. By contrast, Cairns has 3800 buildings and Mackay 2170 buildings likely to have overfloor inundation from a 1% AEP storm tide (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). The number of properties with overfloor inundation increases to about 44 000 in a 0.01% AEP (10 000 year ARI) storm tide event. This represents about 6.7% of all developed properties in the region. The neighbourhoods that do have a high storm tide risk index tend to be in the areas of older residential coastal development (particularly Bongaree, Brighton, Lota and Sandgate); rural or rural village-type communities (e.g. Beachmere, Boondall, Ningi, Nudgee Beach and Toorbul); some of the more modern canal estates (most notably Birkdale, Cleveland and Hope Island); and some of the areas containing commercial/industrial development on the lower reaches of the Brisbane River (e.g. Albion, Hemmant and Pinkenba). It is apparent that most of the LGAs that have a recognised storm tide risk in the region have established, or are moving to establish, the 100 year ARI storm tide level for their planning threshold.

Tropical Cyclone Wind: Analysis of tropical cyclone wind impact on the region indicates a low to moderate level of risk. For the 1% AEP (100 year ARI event) an equivalent damage loss of 150 insured dwellings with contents can be expected. This increases to 1500 dwellings for the 0.01% AEP (1000 year ARI design event), or, 0.23% of total insured value of building and contents for the region. The expected damage to older settlements near the coast is estimated to be almost 100 times greater than the average residential damage across the entire region. Brighton, Sandgate, Shorncliffe, Wynnum, Manly, and Lota are examples of those suburbs most at risk of damage. Coolangatta, Surfers Paradise and Burleigh Heads are also expected to suffer significantly higher wind damage than the regional average. Residences that are not shielded by other buildings, such as those in semi rural areas, are also expected to suffer higher damage rates than residences of similar age in more densely urbanised settlements. Tree and branch-fall also represents a significant threat to assets such as buildings, cars and telecommunications. Roads can also become blocked and underground utilities dislocated.

Earthquake: The level of earthquake risk in South-East Queensland is low to moderate when considered on a regional basis, and earthquakes should be considered in risk management strategies for the region. Although damaging earthquakes are relatively rare in Australia, the high impact of individual events on the community has made them a costly natural hazard. There have been few reports of earthquakes causing significant damage in South-East Queensland. However, we need to be aware of the short historical record and the consequences of a rare, damaging earthquake, such as the magnitude 6.3 offshore ‘Bundaberg’ earthquake in 1918. Although overall hazard is low, it is higher in the many parts of South-East Queensland that are built on unconsolidated sediments or on Tertiary geological units. These ground conditions are expected to amplify the ground shaking from future earthquakes. The amount of damage likely to occur in a design level event (a 0.2% AEP earthquake) would equate to the total damage to about 2000 dwellings.

South-East Queensland faces a moderately low risk to its residential buildings from earthquakes. We rate the vulnerability of South-East Queensland residential buildings to earthquake as low. The great majority of residential buildings in South-East Queensland (an estimated 95%) are of light timber frame construction. Timber frame buildings perform well in earthquake and this is a positive factor in the earthquake risk that South-East Queensland faces.

East coast lows: The major impact of east coast lows on South-East Queensland will be in terms of potential storm tide and severe waves, wind damage and flooding. These hazards pose a significant threat of both fatalities and economic loss in localised areas. The incidence of these types of storms can fluctuate from one year to the next. 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 coastal areas can be severe, frequently with loss of life and property from flooding and maritime incidents. We have not, however, quantified the level of that risk.

Thunderstorm: Thunderstorms can bring with them destructive winds, hail, heavy rainfall, lightning and tornados. This analysis estimates the 100 year ARI wind associated with thunderstorms to be about 170 km/h and the 1000 year ARI winds at about 220 km/h, while reports have been made of accompanying hail up to 120 mm in size. The South-East region is particularly susceptible to severe thunderstorms, especially during the summer months. It can be anticipated that at least one damaging thunderstorm could impact somewhere in South-East Queensland in any given year with about 20 occurring in the region. The frequency of these events appears to be increasing. Whilst the areas affected will be much smaller than that affected by a tropical cyclones or east coast lows, the impact could still be both lethal and destructive. We have not, however, quantified the level of risk.

Heatwave: At least 18 heat wave events have been identified since 1899 giving an ARI of, at most, 5 to 6 years. January is clearly the most common month in which heat waves occur. At least 681 deaths have occurred as either a direct or indirect result of heatwave in Queensland. Anecdotal evidence indicates that many elderly people, and indeed many people in other susceptible groups of the population, are largely ignorant of the risks posed by heat waves, or of the simple steps that can be taken to reduce those risks. There is clearly a need to improve public awareness. We have not, however, quantified the level of risk.

Landslide: Within the Gold Coast hinterland region and in particular the Canungra-Beechmont, Numinbah, Tamborine, Springbrook Plateau, upper Tallebudgera and Currumbin valley areas, the risk posed from landsliding from a 100 year ARI rainfall event is low to moderate. On slopes $>25^\circ$ a maximum of about four fatalities and up to two dwellings could be destroyed. Individuals living in the Beachmont basalt geological unit are particularly at risk. On slopes $<25^\circ$ the number of fatalities is significantly less at about 0.3, with about 2.7 dwellings destroyed. Roads traversing slopes $>25^\circ$ are few, however the 13 km of road in these areas is on average expected to be blocked a total of three times. Some sections of roads on slopes $<25^\circ$, are expected on average to be blocked or partially blocked every 1 to 2 km and have a section destroyed by landslide about once every 5 km. In the Caboolture, Pine Rivers, Brisbane, Ipswich, Redcliffe and Redland areas the risk posed by landsliding is very low and it is unlikely that existing buildings would be destroyed or people killed by landslides on cut slopes.

Bushfire: In the context of this study, which has an emphasis on the urban environment, the primary risks posed by bushfires are to those areas on the urban fringe. The key risk is to buildings and to those elements of infrastructure that are either flammable (e.g. timber power poles and wooden bridges) or susceptible to the heat generated by bushfires (e.g. power supply switching gear and electronic equipment). People are also at significant risk, especially if they are caught in the open or in vehicles that are inadequately protected. This risk was highlighted recently by the deaths of several fire fighters in other states and the serious injuries suffered by nine volunteer fire fighters near Beerwah (the so-called 'Bell's Creek fire') in November 1994.

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 Risk

The development and implementation of risk management strategies for South-East Queensland lies outside the remit of the *Cities Project*. Our experience in working with people involved in emergency risk management in South-East Queensland and elsewhere, has, however, given us some insight into key aspects of risk reduction that are offered here as observations, rather than as suggestions. They are certainly not put forward as recommendations.

As has been emphasised at several stages in this study, the only way to reduce or eliminate risks posed by natural hazards is to reduce or eliminate one or more of the three risk variables – the hazard, the elements exposed to the impact of that hazard and the vulnerability of those elements. For any tangible steps to be taken, however, a strong risk culture and the information to sustain it must be developed.

Risk culture: At a philosophical level at least, one of the most potent forms of risk minimisation is the development and nurturing of a strong risk management culture across the community. It has, for example, been frequently observed that emergency risk management is most effective where it is an integral part of overall community risk management. Similarly, disaster planning is most effective where it is managed as an integral part of total community planning. In the vast majority of cases, however, these processes and activities tend to be divorced from the mainstream of community governance, even within organisations that are clearly committed to public safety, as are each of the LGAs in the study area. The compartmentation and isolation of emergency risk management from the mainstream of community governance can best be attributed to the lack of a broadly-based culture of risk management.

Risk management has clearly taken root amongst the LGAs in the South-East Queensland study area, though it is still at an early, and perhaps, fragile stage of development. This commitment can be largely attributed to the pioneering efforts of various LGA disaster coordinators, engineers and planners since the 1980s. The activity is clearly underpinned by the development and promotion, by the Department of Emergency Services (DES), of practical guidelines for local governments to follow in pursuing ‘disaster risk management’ (Zamecka and Buchanan, 1999).

A mature risk management culture will see the decisions made by the executive, administrative, public health, planning, environmental, engineering, fiscal, legal and emergency management elements become more integrated, consistent and coordinated. The outcome would see the interdependencies of strategic decisions in each of those areas acknowledged and their consequences taken into account in a more transparent and seamless process. Such an approach would also tend to widen the planning timeframe from the current two or three year, electorally constrained, horizon to one of 10, 20 or even 50 years.

Risk information: For a comprehensive risk management culture to flourish, it is necessary for it to be underpinned by a strong and effective information infrastructure. We see the development of such an infrastructure as being the most fundamental of all risk reduction strategies. It is also one of the most cost effective strategies, given that most of the information required is already collected, maintained and used by South-East Queensland LGAs and the other authorities that have a role in community risk management. This aspect is considered in detail in a report on the *Cities Project’s* experience of implementing key aspects of the Australian Spatial Data Infrastructure (ASDI) in the Cairns case study (Granger, 1998). A similar strategy was adopted for this study.

Whilst much of the basic information required for risk management, such as street layout, property information, land use and demographic aspects, is already available, there are several themes that we have found to be poorly addressed. Three themes stand out:

- historical information: whilst the Bureau of Meteorology, QUAKES and AGSO maintain their own information on hazard history, and other bodies in the community such as local historical societies, libraries and media outlets each maintain collections on the community’s experience

of disaster, there is no consolidated index or coordination of information about the South-East Queensland history of disasters and their impact on the community;

- modern event experience: South-East Queensland has not experienced any significant disaster impacts for several years so there has been little need for post-event research to be conducted, as has been the case in Cairns, for example, following Cyclones *Justin*, *Rona* and *Steve*. Much of this post-event information, such as the recording of earthquake aftershocks or the nature of flood damage, is highly perishable – if it is not collected during the event it will be lost forever. Without such detail of real events it is not possible to reduce the uncertainty that exists in our models and basic information. The requirement to collect key event information needs to be entrenched in the doctrine of disaster response, with appropriate resources identified in disaster plans and made available to undertake the collection and management of that information; and,
- technical information: much background technical information is being routinely collected by commercial consultancies to meet the requirements of various standards such as the Australian Building Code. The collection and analysis of geotechnical information on which to base the design of building foundations is a case in point. This information is of great significance to improving the accuracy and relevance of risk assessments. Whilst there are obvious commercial (and possibly legal) sensitivities concerning such information, its value to the wider aspects of community safety is not being realised because there is no central inventory of the existence of such information – let alone an archive of the detail.

There has been significant public investment in the development of systems to monitor hazard phenomena and to provide warnings of an impending impact. This important investment has not, however, been matched by the level of investment in information that enables the warnings or risk forecasts to be translated into information of relevance to members of the community. There is clearly a need for a greater level of investment in risk information.

Emergency management: The emergency management process has been based on consideration of the prevention, preparedness, response and recovery phases of disasters (known as PPRR). Under the adaptation of *AS/NZS 4360:1999* to emergency risk management, these traditional components of emergency management can be seen as risk treatment options. The emphasis is on the treatment of residual risks (i.e. the risks that can not be eliminated or reduced by other means), especially in the preparedness, response and recovery phases. Most risk reduction options, however, clearly focus on prevention.

The preparedness phase emphasises disaster planning, community awareness, training and exercising and the provision of appropriate resources such as communications equipment (see EMA, 1993). It is important, therefore, for emergency planning to be based on sound risk assessments and realistic risk scenarios, otherwise plans may be inappropriate, awareness will be inadequate, training and exercises will not be based on realistic scenarios and resources may not be appropriate. Evacuation planning provides a good example. If such plans are based on an assessment that badly underestimates the numbers of people at risk and the timing for an evacuation, many people could be placed in serious jeopardy by reacting too late and with too few resources. Conversely, if the estimates are too conservative, large numbers of people who did not need to be evacuated could easily overwhelm evacuation resources and shelters.

The detailed information and decision support tools provided to South-East Queensland LGA as a result of this study can be used to produce threat-specific plans on which to base all aspects of the preparedness phase. They enable, for example, the development of disaster response and recovery plans for specific levels of cyclone or flood risk, well in advance of any event, and to use the scenarios on which they are based to run realistic exercises and training serials.

The risk scenarios also provide a capacity to model and forecast impact consequences so that the response phase can be managed more effectively. In Cairns in 1999, for example, the data developed under the *Cities Project's* Cairns multi-hazard risk assessment was used by the local counter disaster staff together with the Cairns City Council's own flood model data to forecast the likely impact of the flood that was developing in the Barron River following the passage of Cyclone *Rona*. The information derived from this scenario modelling was then used to successfully plan and carry out the evacuation of more than 1500 people, assessed as being at risk, before the flood peak was reached. That evacuation was conducted at 2.00 am!

The same modelling is also appropriate for rehearsing and planning for the recovery phase. There are examples in the literature of GIS being used to model the impact of a damaging earthquake and to forecast the requirements for short term and long term post-event shelter. Similarly it is possible to model the physical impact on lifelines and the consequences of their loss on the community.

Use of the scenario analysis technique develops 'future memory', i.e. disaster responders develop an understanding of what will happen when such an eventuality occurs so that their actions are based on 'experience' when it eventually does happen. This process could be reinforced by the development of role-play simulation 'games', such as *SimCity*, designed around real South-East Queensland urban centres.

Reducing hazards: Apart from reducing or eliminating bushfire fuels, and stabilising some slopes to prevent landslide occurrence, we have no capacity to reduce the magnitude or severity of any natural hazard phenomenon. On present indications, however, over the next 50 years at least, climate change and an associated rise in sea level are likely to increase both the incidence and severity of most hazards that have an atmospheric origin, including tropical cyclones, storm tide, floods, storms and landslides. Climate change may also increase the incidence and/or severity of heat waves and bushfire. Such changes should obviously be taken into account in planning decisions being taken now to ensure that future risk is at least minimised. It is also important that this process of change is effectively and closely monitored.

Monitoring and warning systems: For all of the hazards considered in this study, with the exception of earthquake, warnings of impending impact are already provided in one form or another. A report produced by the Institution of Engineers, Australia (Institution of Engineers, 1993) provides a useful hypothetical example of the benefits of this approach in the following terms:

*Flood warning systems now feature real time data collection networks linked to computer based flood models. These systems not only identify and track floods down a river but also enable emergency services to quickly assess the impact of various scenarios of increased or decreased rainfall, changing tidal conditions in the lower reaches of the river and varying tailwater effects at the river mouth due to storm surge and wave setup. Based on these scenarios, authorities can take more effective action to save lives and minimise damage to property. Even in a catchment with only one thousand flood prone homes, accurate advanced information on flood levels which enables residents to move contents and motor vehicles to locations above flood waters can result in a saving of \$10 000 per household. **This \$10M savings is a direct benefit to the community every time such a flood occurs.***

(emphasis in original)

The coverage and sophistication of most of the monitoring and surveillance systems is constantly improving. There are plans, for example, to introduce Doppler radar to measure wind speed in storms and cyclones and thus improve both warnings and our knowledge of extreme wind speeds. There is also significant scope to improve on the existing seismic monitoring network in the South-East Queensland region so that instrumental recording of the smaller and more frequent events can help build up our knowledge of the region's seismic environment.

Nonetheless, warning systems will be much more effective if the community is aware of their existence and of the implications of warnings. Whilst there is some scope to improve the timeliness and accuracy of warnings, their value will only be increased when individuals are able to relate warning information to their own circumstances and translate that information into risk reduction action. To achieve this it is necessary to increase public awareness by combining appropriate risk information and warning information.

Reducing vulnerability: It is widely recognised by emergency managers that ‘an aware community is a prepared community’. To put the reverse argument, all of the investment in risk information, warning systems, risk science and emergency planning is completely wasted unless it also influences the community to adopt risk reduction strategies.

Risk communication: An effective strategy of risk communication is essential. For example, a typical public flood warning will be expressed in terms of a height on the reference flood gauge. Few people in urban areas can translate that level, with any certainty, to their own property in terms of how high the water would reach. The value of the warning is consequently diminished because few individuals know what action they should take in response.

A considerable literature on risk communication has emerged over the past decade or so (see, for example, the review by Marra, 1998). One of the most coherent examples we have encountered is that promoted by the US Environmental Protection Agency (EPA). Their approach devolves from the basic tenet that, in a democracy, people and communities have a right to participate in decisions that affect their lives, their property, and the things they value. The EPA approach is based on the following ‘seven cardinal rules’ (word in italics are quoted from EPA, 1988):

Rule 1 – accept and involve the public as a legitimate partner: *the goal of risk communication in a democracy should be to produce an informed public that is involved, interested, reasonable, thoughtful, solution-oriented, and collaborative; it should not be to diffuse public concerns or replace action.*

Rule 2 – plan carefully and evaluate your efforts: *there is no such entity as “the public”; instead, there are many publics, each with its own interests, needs, concerns, priorities, preferences, and organisations.*

Rule 3 – listen to the public’s specific concerns: *people in the community are often more concerned about such issues as trust, credibility, competence, control, voluntariness, fairness, caring, and compassion than about mortality statistics and the details of quantitative risk assessment.*

Rule 4 – be honest, frank and open: *trust and credibility are difficult to obtain. Once lost they are almost impossible to regain completely.*

Rule 5 – coordinate and collaborate with other credible sources: *few things make risk communication more difficult than conflicts or public disagreements with other credible sources.*

Rule 6 – meet the needs of the media: *the media are frequently more interested in politics than in risk; more interested in simplicity than in complexity; more interested in danger than in safety.*

Rule 7 – speak clearly and with compassion: *tell people what you cannot do; promise only what you can do, and be sure to do what you promise.*

Governments, at any level, can only hope to reduce risk if their risk reduction strategies are accepted and supported by the community. Risk communication is the most democratic way of achieving that support.

Efforts to inform the community about risks are not always viewed with the same passion and altruistic values as those held by risk communicators. They are often met with opposition from small, but influential, sectors. The most common negative reactions relate to the belief that such information will have a negative impact on real estate values, and/or, will 'scare away' tourists or investment. Whilst there has been only limited research into the overall economic impact of risk communication, the anecdotal information that we have seen indicates that such negative beliefs are wrong. They do, nevertheless, excite levels of passion and political 'outrage' that typically leads to the dilution, if not termination, of public awareness efforts.

Strengthening buildings: Adherence to building codes is rightly seen as being a very effective strategy for risk reduction, given that much of the losses encountered in disasters come from damage to buildings. All Queensland LGAs enforce the provisions of the Australian Building Code which established minimum standards for construction to safely withstand established levels of earthquake and wind risk. A standard for construction and subdivisional design in bushfire prone areas is also close to publication. Whilst these standards reduce the risk to new buildings, standards and guidelines have also been developed to 'retrofit' older buildings to similar levels of safety against earthquake and wind loads, as described above. Preliminary consideration is also being given to the development of comparable standards for design and construction in areas prone to landslide and to inundation hazards such as flood and storm tide.

It is clear that many existing buildings in South-East Queensland are susceptible to wind, in particular, and to earthquake damage. Councils could compile local databases of these buildings and assess whether mitigating action is necessary. Mitigation schemes could include elements of:

- regulations that make wind or seismic upgrade mandatory when any major renovation, alteration, addition or change of use is undertaken by the owner. *SAA HB132.1* and *SAA HB132.2* (Standards Australia & Insurance Council of Australia, 1999a and 1999b) contain recommendations for structural upgrade of dwellings for severe wind. *AS3826-1998*, (Standards Australia, 1998) contains recommendations for retrofit of buildings for earthquake;
- incentives through rating reductions for buildings that have undergone retrofitting;
- alternatively, disincentives through rating rises that increase over time if no mitigating action is taken;
- incentives to rebuild rather than renovate, alter or add; and,
- a broader State or National mitigation scheme that consults the insurance industry.

Critical facility protection: The loss or isolation of critical facilities such as hospitals, airports, fuel depots, power substations, cold stores and emergency service facilities, will greatly magnify the impact of disaster on the community. Whilst such facilities remain exposed to disaster impact, plans to protect them are called for. Such protection may be as simple as ensuring the priority allocation of sandbags to the facility. It may be as routine as ensuring that the facility has an adequate uninterruptible power supply (UPS) or a stand-by generator with adequate fuel to cover the loss of reticulated power supply. Or it may embrace costly structural defences such as the construction of permanent protective berms or levees and the development of redundant capacity at other facilities that could cope with the potential loss of one component in a critical system.

Such mitigation efforts are targeted to maximise community protection with a minimum of effort and cost.

Reducing exposure: The simplest way to reduce risk is obviously to keep people and development out of areas that are prone to regular and/or significant hazard impact such as floods. Such an approach has already been adopted in South-East Queensland with the various council inundation policies for new development.

Queensland's *Integrated Planning Act* (IPA), which came into force in 1998, also has the potential to be used to reduce community risk. This legislation enables local governments to include, within their urban planning schemes, specific constraints on development that are aimed at managing risk. The IPA does not establish levels of constraint for different hazards, such as an ARI of 100 years as the State-wide constraint for development in floodplains, but leaves the setting of such thresholds to the individual local government.

The IPA also contains provisions that enable councils to change past planning decisions that did not take into account community safety issues. A land use approved under a previous planning scheme can, for example, now be changed without compensation to the owner, but only after the owner has been allowed two years to substantially commence redevelopment on a site with a previous use.

To be effective, however, planning policy must take both a long-term view (preferably with at least a 20-year horizon), and a holistic perspective, especially as the centre of development moves away from historical urban centres as the community expands. This study, for example, has provided new earthquake hazard information. Councils could use that information to ensure that new development does not introduce unnecessary risk. Councils could, for example, adopt the South-East Queensland earthquake hazard map to inform developers and their engineers of ground conditions with regard to earthquake.

The planning regulation corollary to the 'retrofit' codes for existing buildings is the policy of relocation or compulsory acquisition of properties with an unacceptably high degree of exposure. Such programs are usually expensive and marked by controversy, however, they are clearly effective in reducing risk.

Engineered defences for inundation: The classic response to inundation risk mitigation has been to turn to structural defences such as levees, dams, flood detention basins and fill that are designed to reduce or eliminate exposure to the hazard. There is a view, however, that:

- they are invariably expensive;
- they frequently fail to provide the levels of protection that are attributed to them because of inadequate design and/or poor maintenance;
- they foster a false sense of security in the community that they are supposed to protect, with the result that when they fail, the community is exposed to a much greater degree of loss; and,
- the levels on which they are based (e.g. the modelled Q100 flood line) can change dramatically (either up and down) as better science, modelling techniques and information is applied, and as external factors, such as vegetation protection regulations, take effect.

The degree of protection from flood in the Brisbane River afforded by the construction of the Wivenhoe Dam provides a good example. There is a widely held view within the Brisbane community, for example, that the construction of Wivenhoe Dam will prevent a repetition of the 1974 flood, and consequently, Brisbane is now flood-free. Whilst Wivenhoe Dam has undoubtedly improved the management of flood waters, it certainly will not eliminate all floods in the Brisbane River, let alone floods originating in the Bremer River portion of the catchment. The urban myth surrounding the flood prevention capability of Wivenhoe Dam would even appear to have spread to the Logan River - we encountered one story in which some people on the Logan River actually believed that the Wivenhoe Dam provided them with flood protection!

There is an increasing tendency to emphasise non-structural mitigation measures (such as those discussed above) and to regard structural defences as the risk reduction strategy of last resort. Where structural mitigation is being considered, however, the risk assessment methodology we have employed in this study provides the basis on which to undertake a cost-benefit study. The risk assessment approach also enables proposed risk reduction strategies to be modelled and their effects tested against the criteria that they aim to meet.

The Wider Picture

This study has concentrated on the risks posed directly to the South-East Queensland community. Where appropriate, however, attention has been drawn to factors that lie outside the control or influence of the South-East Queensland community that may exacerbate those risks. Attention has also been drawn to facilities located within South-East Queensland, the loss or isolation of which could have significant consequences beyond the borders of the LGA in which they are sited. It is appropriate, therefore, to consider the risks to South-East Queensland in a wider geographic context.

Clearly, the most significant factor that influences the vulnerability of the South-East Queensland community is its reliance on external sources for all of its fuel, most of its power supply and much of its food, water and personal requisites. The dislocation of any or all of these services, or their isolation from South-East Queensland, would have a very significant impact on the South-East Queensland community, even if South-East Queensland itself were not directly affected by the particular hazard impact. The loss of supply from the Gladstone power station, which generates half of the State's total power, for example, would greatly reduce the amount of energy available for use in South-East Queensland. The isolation of the major fuel storages and refineries at the mouth of the Brisbane River, for example, could see many motorists, transport operators and plant operators run out of fuel in two to four days. There is little, if any, redundancy to provide an alternate supply to the South-East Queensland.

Brisbane, through its history and size, is clearly the economic and administrative 'centre of gravity' for the South-East Queensland region. It is natural, therefore, that most of the region's high-order and strategic services are located within its boundaries. The distribution systems that support them are also, by necessity, extremely efficient. It is a highly productive and prosperous arrangement which has undoubted economic, administrative and political benefits - under 'normal' circumstances. Under the conditions experienced in disasters, however, such a concentration could significantly **increase** community risk, not only to Brisbane City, but to the entire region, if not the whole State and significant portions of northern NSW, especially if key resources and distribution infrastructures are sited in locations that have a significant exposure to hazard impacts. Such circumstances may not be all that 'abnormal', especially if one takes a view of risk that is somewhat longer than the term of elected officials or the construction phase of a major development project. It is not until one takes a longer temporal and wider regional view of risk that the significance of these issues becomes apparent.

Under existing legislation and administrative arrangements in Queensland there is little that individual local governments can do to influence planning and development decisions in other local government areas that have the potential to impact on their long-term safety and sustainability.

Given that it is more than 25 years since the last significant disaster event in South-East Queensland, there is a significant degree of ignorance and complacency in the wider community regarding risk. A concomitant reluctance on the part of policy makers to commit to community safety has also been evident, especially if it is perceived to be at the expense of 'development'. There are indications, however, that this situation is changing. This wind-shift is, in no small way, attributable to the publication of *AS/NZS 4360* and its adoption by the Department of Emergency Services as the basis for emergency risk management throughout the State. It has also been given some additional focus by changes to the guidelines that govern the Natural Disaster Relief Arrangements (NDRA) payments from the Commonwealth.

The Commonwealth Government revised its NDRA guidelines in 1998. The continued payment of the Commonwealth funding contribution to the restoration of public assets following disasters has been made explicitly conditional on there being evidence that the receiving public body (State or local government) can demonstrate that they have taken steps towards reducing the risks posed by recurrent hazards in the area that was affected. It should be noted that NDRA payments are only designed to return damaged assets to their pre-disaster state – it does not cover the costs of upgrading the assets to reduce their risk exposure. It is important to note that if mitigation measures are not increased in Queensland, the State risks not only recurring damage from disasters but also an increased shift in the NDRA cost burden from the Commonwealth Treasury to the State Treasury.

Queensland authorities see the principal challenge for the continued success of this ‘wind shift’, from an emphasis on response and recovery, to one of mitigation and risk reduction, as being one of securing the necessary funding through the establishment of a ‘National Disaster Mitigation Fund’. Queensland has been an advocate of such a fund, with the Premier writing to the Prime Minister in 1999 seeking the Commonwealth’s support. To date no progress has been made (Lesley Galloway, DES, personal communication, 2000).

Queensland authorities have also begun to develop a strategic view of risk mitigation at the State level. In December 1998, the Queensland Cabinet established the State Disaster Mitigation Committee (SDMC) to improve disaster mitigation in Queensland. The SDMC is a whole-of-Government committee, with representatives from ten State Government Departments (chaired by the Director-General, Department of Emergency Services (DES)), two Local Governments and the Local Government Association of Queensland (LGAQ).

From material provided by DES, the role of the SDMC is:

To provide advice to the Minister for Emergency Services on disaster mitigation issues through the Central Control Group of the State Counter Disaster Organisation (chaired by the Director General, Department of State Development).

The efforts of the SDMC are designed to assist LGAs with planning for disaster mitigation, together with developing whole-of-Government strategies to incorporate disaster mitigation considerations in the full range of legislative and planning frameworks. These include a State Planning Policy on land use planning for disaster mitigation (under the *Integrated Planning Act*); the proposed State Infrastructure Plan (being developed by Department of State Development); and the State’s capital works programs.

The SDMC has:

- defined disaster mitigation as ‘the process of identification and analysis of potential hazards with a view to formulating options and strategies designed to reduce risk and minimise the effects when disasters occur’;
- established the parameters of an all-hazard risk management approach by developing a comprehensive reference book, *Disaster Risk Management* (Zamecka and Buchanan, 1999), which is based on the practical application of the *AS/NZS 4360:1999*. A companion guide, *The Disaster Risk Management Guide: A How-To Manual for Local Government*, has also been developed by DES;
- commenced the determination of criteria to be used in setting priorities for disaster mitigation across the State;
- evaluated existing Commonwealth and State programs’ abilities to fund disaster mitigation activities;

- developed funding criteria for the \$3 million Natural Disaster Risk Management Studies Program (NDRMSP) which was formally released by the Commonwealth Minister for Finance and Administration in March 2000; and
- conducted a broad disaster awareness and education program directed at Local Governments and the community.

Whilst the State-level strategy is being addressed by the SRMC, it is perhaps significant that the South-East Queensland Regional Organisation of Councils (SEQROC), the strategic grouping of the 18 local government councils of the South-East, do not have a 'risk mitigation' or 'risk management' working group. They do have:

- a Planning Working Group to look at regional strategic planning issues;
- a GIS and IT Working Group which provides a forum for GIS and IT officers with the view to maximising compatibility of systems and to address standards issues;
- an Environmental Health Working Group to consider regional health and hygiene issues, animal management and related regulations;
- a Waste and Recycling Working Group to develop a uniform approach to waste management;
- an Environmental Management Working Group to consider regional approaches to issues such as vegetation and waterways management;
- a Rural Issues Working Group to consider issues such as rural viability and service delivery;
- a Transport Working Group that considers regional transport planning proposals;
- an IT and Knowledge Based Clusters Working Group to, amongst other objectives, promote e-commerce for small and medium businesses across the region;
- a Telecommunications (Facilities) Working Group to develop common approaches to the siting of mobile phone towers; and
- a Biosolids Working Group to investigate options for the disposal of sewerage sludge, etc.

Whilst some of these working groups undoubtedly take into consideration issues of community safety, there is no working group established explicitly to consider, coordinate policy or to make recommendations on issues of community safety and risk reduction on a region-wide basis. Hopefully, this study will prompt SEQROC and its member councils to consider such an addition.

The existing disaster management arrangements also seem to work against a regional approach to risk management. Each local government is responsible, under the *State Counter Disaster Organisation Act*, for developing its own local disaster plan. There are also district disaster plans drawn up to cover 'disaster districts'. These districts are based on the QPS Districts, which have been designed to maximise police administrative efficiency, not the provision of disaster management. Brisbane City, for example, is split between two police districts with the Brisbane River as their common boundary – not an ideal arrangement when considering flood management, for example.

A region the size, complexity and significance of South-East Queensland probably demands a different disaster management arrangement to make regional risk reduction an explicit objective rather than an afterthought once the disaster has happened.

Where to From Here?

At the beginning of this multi-hazard risk assessment of South-East Queensland we stated that it was 'a starting point, rather than an end in itself'. This needs to be restated at the conclusion.

There is opportunity to build on this assessment. For example, there has been a deliberate avoidance of undertaking economic assessments of potential loss as there are not the sufficiently complex models and data on which to base such an assessment at this time. It is clear that to enhance this assessment with a soundly based economic dimension would be a relatively minor undertaking with major advantages. We have also confined our assessments to scenarios that are based on present-day climatic conditions. Further work is required to understand the longer term risks associated with climate change, especially where it relates to sea level rise and the possible increase in the frequency and/or severity of cyclones and intense rainfall episodes.

A general lack of data has limited our consideration of the risks to lifelines such as power and water supply and their interdependencies. We are confident that those data will become available in the future and when they do, this study should be updated and its assessments re-evaluated.

Turning the information and the risk assessments provided here into risk reduction strategies is a task for others, particularly the South-East Queensland LGAs and their respective communities.

We are greatly encouraged by the action that has already become evident in the region and elsewhere. A strong level of commitment to risk management is beginning to emerge. We are confident that South-East Queensland is well on the way to becoming a much safer, more sustainable and prosperous community.