4 Forecasts, warnings and information

4.1 Flood warning systems

A flood warning system is made up of at least the following elements:

- prediction of flooding, usually by reference to river height
- interpretation of the prediction to determine the likely flood impacts on the community
- dissemination of warning messages about likely flood impacts to authorities and the community
- response to warning messages by the community and authorities.

In Queensland, responsibility for each of these components is divided between several agencies.

The Bureau of Meteorology has primary responsibility for the first element in the flood warning system: the prediction of flooding. The Bureau also has responsibility for providing warnings about weather conditions likely to give rise to floods.[1] It disseminates this information to state and local authorities and the public.

Councils bear the primary responsibility for translating flood predictions into the likely impact of flooding on local communities. As part of this role, councils are expected to provide information to the community about inundation at individual properties.

Dam operators may also play a role in flood warnings by distributing information about expected and actual outflow from dams, and data obtained from river height or rainfall gauges owned by the dam operator. This information is commonly used by councils and the Bureau to predict river heights and flooding. Dam operators are not generally involved in warning the community directly, although there is a narrow set of circumstances in which it is appropriate for them to do so.

The responsibilities of each of these agencies are interrelated; they should work together to provide effective flood warnings to the community.

This section examines issues related to two of the flood warning system elements listed above: *dissemination* of warning messages and *interpretation* of flood level predictions. In particular, it considers the effectiveness of warning mechanisms used by councils and disaster management organisations, and the information provided to the community about flood levels and road conditions. The section also outlines the role of dam operators in providing information relevant to flood warnings.

Issues relevant to the role of the Bureau, and specific warnings provided by the Bureau to councils and the public, including those in Toowoomba and the Lockyer Valley are examined in *4.2 Warnings and forecasts: Bureau of Meteorology and councils*.

4.1.1 Warnings

Effective warnings and information about flooding help the community and authorities to protect lives and property. The Queensland Floods Science, Engineering and Technology Panel convened by the Queensland Office of the Chief Scientist, identified that to be effective, a warning must be, amongst other things, informative, accurate, timely and trustworthy.

When providing warnings and information about flooding to the community, local and state authorities, and the Bureau, should take into account the particular needs of people from non English speaking backgrounds and the deaf community.

Community education is also vital to ensure that warnings are understood by their intended recipient and elicit an appropriate response. See chapter *3 Disaster frameworks, preparation and planning* for a more detailed discussion of community education.

During the 2010/2011 floods, the community received warnings and information by the following means:

- SMS alerts ('short message service', or text message)
- radio and television announcements
- social media such as Facebook and Twitter
- media releases and community service announcements
- information posted on websites
- door knocking.

No single warning mechanism is effective in all cases; some work well in some communities, or in some circumstances, but not others. Where flash flooding occurs or communities are threatened by rapidly rising water, a mechanism that can deliver immediate warnings should be used. Using a range of warning mechanisms helps to make sure that warnings reach all members of the community at risk of flooding, are effective for particular locations and are received even when power is lost.

Recommendation

4.1 In issuing warnings for a district or region, local and state authorities should use a range of different warning mechanisms effective for the particular district or region, including methods which do not rely on electricity.

Specific warning mechanisms

SMS alerts

In Queensland, there are three types of SMS alert systems. Emergency Alert is a national warning system that allows SMS alerts and recorded voice messages to be sent to affected individuals and businesses.[2] In Queensland, Emergency Alert is managed by Emergency Management Queensland.[3] Brisbane City Council and Townsville Regional Council have engaged a private company that sends SMS alerts, emails and recorded messages to individuals and businesses who have subscribed to the service.[4] Some councils have developed their own SMS alert systems. Generally, SMS alerts were an effective method of delivering flood warnings and information in the 2010/2011 floods.[5]

However, SMS alerts containing insufficient information are of little use, and can be positively harmful. An SMS alert sent to residents of Moreton Bay council region contained the following message:

> Immediate Flash Flood Warning for Caboolture, Burpengary Area. Very high water levels in Rivers and Creeks. Seek higher ground NOW.[6]

It caused confusion and even panic in some of those who received it.[7]

The problem, of course, is that the information SMS alerts can contain is limited to 160 characters. Consequently, SMS alerts work better when the text, as well as including critical information, refers recipients to other sources of information about what to do and where to go.

Some councils experienced delays when sending SMS alerts to residents, caused by the time taken to draft the text of the alert and identifying which residents should receive it. Councils need to understand the risk of flooding in their region so they can quickly determine which residents should receive an SMS alert and what that alert should say.

It is critical that such delays are avoided because SMS alerts must be timely in order to provide effective warning. An SMS sent by Ipswich City Council was received by some residents after their properties had been inundated.[8] Moreton Bay local disaster management group decided against sending an SMS alert to warn residents about dam releases because, by the time it was ready to be sent, the dam releases had peaked.[9] Since the January 2011 floods, both of these councils have decided to create message templates specific to each community that is at risk of flooding.[10]

SMS alerts are also not a reliable method of providing flood warnings in parts of Queensland which experience problems with telephone coverage. That difficulty is compounded during a flood, when telephone reception can be affected by flood related power outages and congested telecommunications networks.[11]

While any SMS alert system may have problems of the kind described, some particular limitations of the Emergency Alert system emerged during the 2010/2011 floods.

In Queensland, the use of Emergency Alert is governed by the Emergency Alert Operational Guidelines. The guidelines stipulate that, during a flood or severe weather event, Emergency Management Queensland or the state disaster co-ordination centre must approve an alert before it is issued. The approval process can take between 30 and 95 minutes;[12] two councils expressed concern that this process reduced the timeliness of Emergency Alerts sent.[13]

Councils and local disaster management groups should be aware that the Emergency Alert system cannot deliver alerts to all intended recipients instantaneously.[14] The time it takes for all Emergency Alerts to be delivered depends on how congested the telephone networks are, and the number of individuals who need to be warned.[15] According to the Director-General of Emergency Management Queensland, in some circumstances, it can take some hours for all SMS alerts to be sent.[16]

While councils often request that an alert be sent, Emergency Management Queensland or the state disaster co-ordination centre can issue an alert on their own initiative if immediate action is needed. In the Moreton Bay council area and the Somerset council area, SMS alerts were sent to residents by the state disaster co-ordination centre without the knowledge of the local disaster management groups.[17] In Moreton Bay, this meant that the council was not able to cope with the large volume of calls (approximately 5000) the council's call centre received after the SMS alert was sent.[18] To make matters worse, the local disaster management group was not in a position to provide information about what particular areas should be evacuated or the location of any evacuation centres.[19]

There will be occasions when a threat is so imminent that the state group must send an Emergency Alert without the knowledge of a council or local disaster management group. However, wherever possible, the state group should inform the council or local group of Emergency Alerts so the council or local group can prepare and provide appropriate supplementary information to members of the community.

At present, Emergency Alert delivers SMS alerts to residents based on their billing address. This meant that during the 2010/2011 floods some residents received alerts about flooding in Queensland while they were overseas.[20] Conversely, those who are visiting an area affected by flooding will not receive an SMS alert because their telephone billing address is elsewhere. The SMS alert operator for Brisbane City Council has the capacity to provide alerts to people based on their location (location based warnings).[21] However this function is not currently available Queensland wide. Victoria, on behalf of the Commonwealth Government and other state governments, is working with telecommunications companies to develop the capacity for Emergency Alert to send location based warnings.[22]

Following the use of Emergency Alert during the recent floods and Cyclone Yasi, the Commonwealth Government has commissioned an independent review of Emergency Alert to assess whether the system provides timely and adequate information. The outcomes of this review are expected to be considered by the National Emergency Management Committee in the latter part of the year. (The role of the National Emergency Management Committee is described in *3.5.2 Driving in floodwaters*.)

In addition, the Queensland Police Service and Emergency Management Queensland are reviewing the current version of the Emergency Alert guidelines. This review will incorporate comments made by district disaster

co-ordinators and district disaster management groups about the performance of Emergency Alert during the 2010/2011 floods. These comments reflect some of the problems identified by the Commission.

The State Government has indicated that the new Emergency Alert guidelines will be completed by the next wet season. It is important that this goal is achieved so local and state authorities have sufficient time to familiarise themselves with the new guidelines and any new procedures.

Recommendations

4.2 Councils should prepare SMS alert templates covering a range of different flood scenarios before the wet season.

4.3 SMS alerts should direct recipients to websites or contact numbers providing more detailed information about flood locations and predictions, the location of evacuation centres and evacuation routes.

4.4 Councils and Emergency Management Queensland should work together to ensure the approval process does not cause delays in delivering SMS alerts.

4.5 Wherever possible, Emergency Management Queensland should consult with local disaster management groups before sending emergency alerts to residents. Emergency Management Queensland should inform the local disaster management group, as soon as it can, about any message already sent to residents in that local disaster management group's area.

Radio

The 2010/2011 floods demonstrated the importance of radio as a means of communicating natural disaster information to the community.

Radio is an effective means of communicating information to isolated communities where internet and mobile telephones are either not available or not reliable. Battery operated radios have the particular advantage of continuing to function after power has been lost. One local commercial radio station, with a local electrical appliance retailer, organised a successful initiative before the floods to encourage the community to purchase discounted battery operated radios.[23]

The community relies on radio as a source of information about local conditions during a disaster. During the floods, radio stations broadcast information from members of the community about road closures, unofficial evacuation centres, where to go, and what to do in their particular area.[24] Radio stations in Ipswich and Moreton Bay gave accounts of their telephone lines being overwhelmed with calls from listeners seeking, and wanting to provide, information.[25]

For many regional communities, ABC local radio is an essential source of information. The ABC was widely commended for its coverage of the floods. Councils in regional Queensland recognised that ABC radio is critical for the dissemination of information, and worked closely with the ABC to provide warnings to their communities.[26] One local disaster management group even arranged for a representative of ABC radio to be on site at the co-ordination centre during the flood response.[27] The ABC has indicated it is willing to work with councils to ensure that residents are aware of the ABC radio frequency that will provide warnings and other information during future floods.

In some instances, a radio station's frequency covered a geographical region experiencing flooding at a number of locations. For example, the Banana Shire Council is covered by three different ABC radio frequencies. These frequencies also cover parts of Western Downs Regional Council. Because of this, during the 2010/2011 floods, the ABC radio frequency that covers both Banana Shire Council and Toowoomba city focussed its coverage on the events in Toowoomba. As a result, Banana Shire Council could not assume that residents listening to that frequency would receive timely information for their area. The Banana Shire Council is currently discussing this particular issue with the ABC.[28]

Recommendation

4.6 Individuals and businesses should be encouraged to acquire battery operated radios for use in emergencies.

4.7 Councils should ensure that residents are aware of the frequency of the radio station or stations in their local area that will disseminate flood warnings and other information during disasters.

See chapter *3 Disaster frameworks, preparation and planning.*

Social media

During the 2010/2011 floods, some councils and the Queensland Police Service used social media such as Twitter and Facebook to disseminate flood warnings and information about local conditions.

Where it was used, social media was found to be an effective way to provide information to the community.[29] An independent review of the Brisbane City Council's response to the January 2011 floods determined that Facebook and Twitter were used extensively to access information about the 2010/2011 floods.[30]

Many of the councils that do not currently use social media to provide information to residents have indicated an intention to do so in future disaster events.[31]

As it may be possible for the public to post information directly to an official social media site, there are concerns that a member of the public might post false information.[32] For example, inaccurate information was published on the Western Downs Regional Council Facebook page.[33] The Commission acknowledges that additional staff, beyond the resources of some councils, may be needed to prevent inaccurate information being posted. However, where there are enough staff to monitor content, social media can be a useful tool to respond to rumours in the community. For example, two employees of Goondiwindi Regional Council updated the council's Facebook site 24 hours a day to correct rumours promptly and to provide up-to-date information to the community.[34] The Queensland Police Service also used its Facebook site to respond to rumours; for example, a rumour about the failure of Wivenhoe Dam.[35]

Recommendation

4.8 Councils that have not already done so should consider how social media may be used effectively to provide accurate information about flood levels and local conditions to residents during a flood event.

Sirens

Sirens were not widely used in the 2010/2011 floods. However, when the threat of flooding is imminent and is confined to an identifiable area, a siren may be an effective means to warn the community.

Since the 2010/2011 floods, residents in Fernvale and the Lockyer Valley have proposed sirens as an effective means of warning their communities, given the susceptibility of these locations to rapid rises in water levels or flash flooding.[36] Goondiwindi Regional Council is also considering using a siren for the town of Killarney, where flooding occurs quickly.[37]

Sirens may also convey information other than an immediate threat of flooding. For example, upon hearing a siren, the community of Condamine gather at the SES shed to hear further information.[38] The Local Government Association of Queensland and Mackay Regional Council have suggested that community members be educated to understand that, if a siren or other signal is played, they should turn on their radio to hear further information.[39]

Recommendation

4.9 A siren may be appropriate in smaller towns or rural communities susceptible to flash flooding. If councils rely on sirens to warn residents, they should ensure that the community understands the meaning of the siren.

Door knocking

During the 2010/2011 floods, door knocking was used to warn residents about flooding in both large and small communities. Door knocking was conducted by council staff, Queensland police, SES volunteers or members of the local community. Providing information directly to individuals is one of the more reliable ways to convey flood warnings. However, because of the time it takes, there may not be enough people or time to warn everyone at risk of flooding.

Door knocking is more likely to be an effective method in areas that are known to be susceptible to flooding, so that there is ample notice and opportunity to warn residents. Some councils commence door knocking of these areas after a certain trigger is reached, such as predetermined river height or certain outflows occurring from a nearby dam. This kind of arrangement exists for residents in Mackay, Moreton Bay, Gladstone and Chinchilla.[40]

Of course, as the area likely to be flooded increases, the ability to door knock all residents is reduced. In Brisbane, as the predictions for the height of the Brisbane River rose on 11 January 2011, the number of properties to be door knocked increased from about 10 000 to 30 000;[41] a number beyond the capacity of Brisbane City Council staff to achieve in time. Nonetheless, if resources permit, door knocking should not be discounted as a warning mechanism for large communities. Brisbane City Council staff were able to reach nearly all of the initial 10 000 properties predicted to be affected before the flood waters peaked.[42]

Some local disaster management groups, rather than arranging for council staff to speak directly to residents, used local sub-groups as a conduit for information to communities affected by flooding. A description of these sub-groups, and the role they played in providing warnings and information to isolated communities can be found at *5.1.2 Locality-based disaster management*.

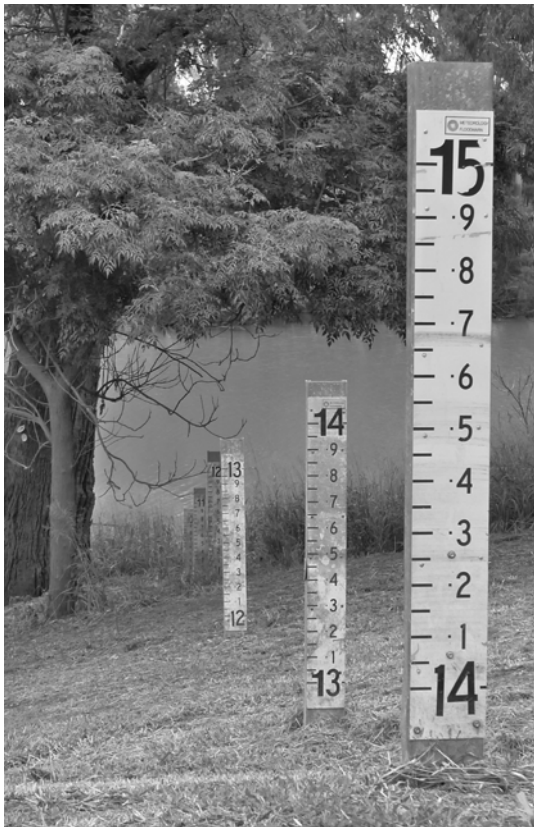
'Bush telegraph'

During the 2010/2011 floods, residents living near water courses in rural areas provided great assistance by warning councils and other local residents about large volumes of water moving through the local systems.

In Jericho and Alpha the accumulated knowledge of local landowners, living on different streams and tributaries, was provided to local police who acted on that information and warned the towns downstream about flooding.[43] Similarly, in the Central Highlands council region, rural residents are able to estimate the likely flood levels downstream in Rolleston by using information about water levels in the Panorama and Brown rivers and Carnarvon Creek, and comparing it to previous floods.[44] Based on this information, residents operate a 'bush telegraph' by calling each other and ensuring those at risk of flooding are evacuated in time.[45]

However, informal flood prediction systems using local knowledge are not always permanent. The town of Condamine lost an important source of information about flooding when the property of a long term resident was sold and the resident moved away from the area.[46]

It is plain that councils, particularly those in rural Queensland, should continue to take advantage of local knowledge about river heights and rainfall.



Flood markers showing water levels at Dawson River, Theodore, photographed after floods (photo courtesy Gerard Hinchliffe)

Gauges

Gauges and flood warning

To warn the community about flooding or severe weather, authorities must first be able to monitor rainfall and water levels and predict further rises in water level. For

this purpose, the Bureau has access to about 2200 gauges across Queensland.[47] About half of these are owned by other agencies such as the Department of Environment and Resource Management, Seqwater, SunWater and local councils. These gauges monitor either river heights, rainfall or a combination of weather conditions (the latter type includes automatic weather stations).

Types of gauges

The gauges used in flood warning can be categorised broadly as either manual or automatic.[48] Automatic gauges can be divided further into two broad categories: telemeter gauges and ALERT gauges.

A telemeter gauge sends river height or rainfall data at periodic intervals to a computer. This data is sent by telephone communication, such as landline, mobile or satellite, and is used by the Bureau and the owner of the gauge.

ALERT stands for automated local evaluation in real time. ALERT gauges comprise a network of river height and rainfall gauges that continuously report data by VHF radio to computers at either a council or the Bureau. ALERT gauges provide a continuous stream of data, but can also be configured to send an email or SMS alert to council staff when a predetermined trigger is reached, such as a certain river height.[49] For example, after receiving an alert, Mackay Regional Council's procedure is to commence door knocking of particular streets at high risk of flooding. The Bureau considers that ALERT gauges are ideal for areas at risk of flooding, including flash flooding.[50]

Installing additional gauges

Many local councils and some residents considered that, located in places of identified need, additional gauges would bolster existing flood warning systems by improving the accuracy and timeliness of predictions about flooding.[51] For example, in Emerald, the council estimated that a strategically located gauge would allow the council 12 to 24 hours additional warning of a potential flood.[52]

Clearly, gauges are integral to predicting flooding and providing timely warnings to the community. However, gauges have a number of limitations, which are discussed in the context of their use by the flood operations centre in section *2.6 Decision-making and conditions at the flood operations centre*.

Where additional gauges should be located, the type to be used and whether additional gauges should be installed at all, depend on a range of factors. These include the type of warning to be achieved, the size of the catchment and the causes of flooding in the particular river system and its tributaries.

The cost of gauges is also a factor to consider. Councils can apply to the Natural Disaster Resilience Program for funding for river height and rainfall gauges required for flood warning purposes. However, even where this funding is obtained, councils are required to contribute to the maintenance of the gauges and any related equipment (such as telemeter equipment for data reporting).[53]

The Bureau considers that councils should initiate the process of obtaining additional river height and rainfall gauges in their council region.[54] Since the 2010/2011 floods, a number of councils have already commenced discussions with the Bureau about installing additional gauges.[55]

Recommendations

4.10 Councils, with the assistance of the Bureau of Meteorology, should examine the feasibility of and priorities for installing additional river height and rainfall gauges in areas of identified need.

4.11 Councils, with the assistance of the Bureau of Meteorology, should consider the susceptibility of their regions to flash flooding, and whether it is feasible and necessary to acquire and operate an automated local evaluation in real time system (ALERT system) for particular waterways.

4.12 The Queensland Government should consider assisting less well-resourced councils to fund the installation of an ALERT system where a case is made for its adoption.

4.1.2 Information about flood levels

Residents and businesses need accurate information about how possible flood levels will affect their properties.

During the 2010/2011 floods, the Bureau, councils, state authorities and the media provided information about predicted flooding to the community. They used a range of methods including references to river heights at certain gauges in terms of AHD (Australian Height Datum), the Q100 level and other technical terms, as well as historical flood levels.

River heights measured in AHD at certain gauges

Flood levels are often described by reference to the height of a river at a certain gauge in terms of AHD. AHD is a unit for measuring height where 0.00 metres is the average sea level recorded at 30 tide gauges around the coast of Australia. For example, in Brisbane, when a river height is described as 4.5 metres AHD at the Port Office gauge, this means that the height of the river is approximately equal to 4.5 metres above sea level at the location of the Port Office gauge.

References to river heights in terms of AHD at a certain gauge are useful for those with technical knowledge, such as engineers or hydrologists working for the Bureau or local and state authorities. Some people understand the significance of river heights described in AHD for potential flooding on their properties. For example, the residents of Dale Street, Burpengary live very near the Burpengary Creek and regularly refer to the Bureau's information about river heights at the Burpengary Creek gauge to assess whether flooding is likely to occur on their properties.[56]

However, references to river heights in terms of AHD were meaningless to some residents and businesses in trying to assess the likely impact of flooding on their properties.[57]

The height of the river measured in AHD is often dependent on the location of the gauge, consequently, residents and businesses need to be aware of which gauge is relevant to their location. For example, the height of the Brisbane River at the Port Office gauge will not accurately predict flood levels in the Brisbane suburb of Archerfield, which is some distance from the Port Office gauge and where flooding is also caused by the nearby Oxley Creek.[58] For residents of this suburb, a river height gauge that measures the height of the Oxley Creek would be a more useful indication of likely flood levels in their area. Information about the location of gauges can be found on the Bureau's website and the locations of some gauges are included in the Bureau's flood warnings. When warnings are provided about river heights, the location of the gauge should be specified.

The actions taken by the Central Highlands Regional Council provide a good example of how information about the river heights at particular gauges can be made understandable to residents. The council's local disaster co-ordinator met with residents of a street at high risk of flooding and advised them what river height at the Fairbairn Dam spillway gauge would result in water over the floors of their houses.[59]

Q100 and other technical terms

Q100, an ARI (annual recurrence interval) of 100 and an AEP (annual exceedance probability) of one per cent are interchangeable terms denoting that every year there is a one per cent chance of a flood of that magnitude or greater occurring at that particular location. A one per cent chance in any one year is equivalent to the average time between such floods occurring being 100 years. The meanings of these terms are not well understood in the community and are often wrongly understood to signify that a flood will occur only once in every 100 years.[60]

Historic flood levels

References to historic flood levels were widely used during the 2010/2011 floods. Such references give a good indication of the likely magnitude of a flood and can help residents get a sense of the potential level of flooding. When residents of Brisbane were advised that they could expect a flood comparable to the historic 1974 flood, it helped them understand the scale of predicted flooding.

Of course, every flood is different and people need to understand that references to historic flood levels are a guide only, and cannot give certainty about whether and to what extent flooding will occur at individual properties.

Communicating the impacts of predicted flooding to residents

While many agencies provide the community with general information about flooding, it is the responsibility of councils to provide information about the likelihood and extent of inundation at individual properties.

Councils can use a range of methods to help individuals easily understand the likely impact of predicted flood levels on their property. For example, Ipswich City Council is considering using a colour coded system for residents to identify whether their properties are likely to be flooded.[61] This system is similar to the Coastal Evaluation system used in some coastal regions to provide information to residents about the likely impact of a storm surge.[62] Brisbane City Council makes flood flag maps and flood wise property reports available to residents, both of which are designed to provide information about when flooding will occur at specific properties.[63]

Other examples include: flood markers, information on rates notices about flooding at individual properties, and geospatial mapping that depicts inundation at certain river heights and is available to the public.

Recommendations

4.13 Councils should ensure that residents and businesses can clearly understand the impact of predicted flood levels on their property. This may include one or more of the following methods:

- information on rates notices about flooding at individual properties
- geospatial mapping, available to the public, that depicts inundation at certain river heights
- flood markers
- flood flag maps and floodwise property reports
- colour coded maps
- information that relates gauge heights with the level of flooding to be expected at a property.

4.14 In the course of flood events, warnings referring to gauge heights should include information about the location of the gauge.

4.1.3 Flood mapping and flood modelling

Flood mapping is the best way for councils to determine the impact of flooding at certain properties. In most cases, a comprehensive flood map is created using a flood model; the latter having been derived from a flood study.

Brisbane City Council has a complex flood model known as 'the Bender' which can account for factors such as fluctuations in tide heights, releases from dams upstream of Brisbane and flows from other river systems and tributaries. During the January 2011 floods in Brisbane, this model was run regularly and was used by the council's call centre staff to provide information to callers about flooding at specified properties[64] and to determine which properties should be door knocked.[65]

The Commission is aware that a number of councils are in the process of creating up-to-date flood studies and flood models.[66]

Current reviews relating to flood mapping

Every council is required to identify in its planning scheme 'natural hazard management areas' affected by floods in accordance with State Planning Policy 1/03 *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide*. The guidelines to the State Planning Policy 1/03 state that 'natural hazard management areas should be identified through a comprehensive and detailed natural hazard assessment study' and provide an outline of possible methods for undertaking flood studies. The natural hazard management area is generally defined by flood maps.

Presently the state and Commonwealth governments are undertaking reviews of flood mapping. In March 2010, the Queensland Government approved a review of the State Planning Policy 1/03 which is expected to take approximately 18 months.[67] The Commonwealth Government's National Disaster Insurance Review has released an issues paper seeking comments on who should bear responsibility for producing, maintaining and funding flood maps and the need for national standards in this area. The review is due to present its report on 30 September 2011.

The Commonwealth review will deal directly with an issue of major concern to some councils: how flood mapping should be funded. This debate arises in part because flood mapping funded by councils also helps other entities, such as essential services providers, to plan and prepare for flooding.

Flood mapping can be a complex, time consuming and expensive process that is unlikely to be completed before the next wet season. Issues relating to flood mapping are likely to be considered by the Commission as part of its investigation into land planning and insurance. In addition, the outcomes of the state and Commonwealth government reviews are still pending. Given those considerations, the Commission will refrain from making recommendations about flood mapping at this stage.

4.1.4 Warnings about dam spillway outflow

This part applies only to operators of referable dams which have a spillway. A 'referable dam' is a dam whose failure places the safety of at least two people at risk.[68] (For a general description of dams see *2.2 Dam history, functions and capacities*.)

The Commission has examined the activities of dam operators during the 2010/2011 floods at various dams around Queensland, including:

- Fairbairn Dam outside of Emerald, Callide and Kroombit dams near Biloela, Beardmore Dam above St George, Coolmunda Dam above Inglewood, Glenlyon Dam near Texas and Leslie Dam near Warwick, operated by SunWater
- Cooby Dam outside of Toowoomba, operated by Toowoomba Regional Council
- Awoonga Dam outside of Gladstone, operated by Gladstone Area Water Board
- North Pine Dam north of Brisbane and Wivenhoe and Somerset dams that sit upstream of Brisbane city, operated by Seqwater.

For the dams outside south-east Queensland (that is, all dams except Wivenhoe, Somerset and North Pine Dam), the operators have no discretion as to when to let water out, and how much, during floods. The dams are either ungated, or have automatic gates which open as the water level increases. Water flows over the spillway of the dam as soon as it reaches a certain height. The spillway of each dam is at a lower height than the dam embankment so that water can flow over the spillway and safely out of the dam. The dams do not have any empty space in them to hold flood water; they are kept as full as possible to provide water for drinking, irrigation and industry. It follows that the Commission's focus has been on the operators' procedures for providing warnings to disaster management personnel and local communities. (See chapter *2 Dams* for a discussion of the operation of Wivenhoe, Somerset and North Pine dams, each of which have flood mitigation capacity.)

The warnings procedures for all of these dams are set out in emergency action plans.[69] Those plans deal with what should be done in all types of emergency, including flood, earthquake and terrorist attack. Each plan is different, but all identify the parties who should be warned about outflow, and the time and manner in which the warning should be given.

Need for warnings about dam outflow

The presence of a dam necessarily affects the manner in which a region floods. A dam is often situated at the convergence of the catchment's flow. Dams can, therefore, be ideal locations at which to gauge water flow during floods, since water from a whole catchment flows out of the dam through a defined area - the spillway. In any case, a dam's presence will affect how water flows toward and down waterways.

Because of those characteristics, dam operators must be involved in the emergency response to floods. It is important that information about lake levels and flows into and out of a dam is received by local disaster management groups, who must make water height predictions for residents and formulate flood warnings.

Local disaster management groups are assisted in their response to flooding by dam operators' sharing information with them. For example, the Mayor of Central Highlands Regional Council described how SunWater staff would not only give useful information to the local disaster management group, but would also participate in phone conferences between council hydrologists and the Bureau of Meteorology to discuss the developing situation.[70] In Emerald, information was shared by email, telephone calls and the presence of SunWater staff at local group meetings; those discussions proved very useful for the local group.[71]

SunWater's manager, Asset Management, Robert Keogh, stated that the sharing of information was easiest when there was an established relationship between the dam operator and the local disaster management group.[72] SunWater has accepted that more work is required to strengthen relationships with some local groups;[73] since the 2010/2011 floods, it has taken steps to ensure its dam staff around Queensland initiate and improve those relationships.[74]

Others who require warnings from dam operators are residents living immediately downstream of dams. Spillway outflow can increase quickly as the result of heavy rain in the catchment. Water can reach those who live, work or own property a short distance downstream of the dam very swiftly. The need for warnings is acute for those residing below dams with gates, because the water flow may increase rapidly when the gates open. Water levels can threaten before the local disaster management group can properly process the dam information and issue a warning. This leads to a confined exception to the general rule that dam operators are not responsible for providing warnings directly to the community. It is recognised in the Australian Government publication *Emergency Management Planning for Floods Affected by Dams*[75] that dam operators must take responsibility for identifying and warning that limited category of people.

The warning of local residents close to Wivenhoe Dam, upstream of Brisbane, provides an example. The dam operator, Seqwater, entered into an agreement with a group of landholders downstream, the Mid Brisbane River Irrigators, to send email updates about current and predicted future releases directly to them. The Commission received some evidence that these communications assisted property owners downstream of the dam to be aware of the developing situation and to take appropriate action to protect themselves and their property.[76] On the other hand, others had difficulty accessing their email during the flood event because of interruptions to the power supply.[77] When power and mobile phone reception is lost, other modes of communication such as radio might be necessary to spread information: see also *4.1.1 Warning mechanisms*.

The DERM *Queensland Dam Safety Management Guidelines*[78] indicate that dam operators should also consider including state emergency agencies, operators of other water facilities, local governments and the Bureau of Meteorology in their list of people to receive information about dam outflow in the emergency action plans. The effective provision of information to those entities would assist in their response to flooding. Given the Bureau's responsibility for providing flood warnings, the provision of information to it is of particular importance.

Recommendation

4.15 Each local disaster management group should include in its meetings a representative of the operator of any dam upstream of its region which contributes water to flooding.

Frequency and content of warnings

Time is of the essence for warnings to local residents who are immediately downstream of the dam, so a short message giving a basic situation report is likely to be preferable. Those recipients need less specific information than local disaster management groups, who require fuller briefings on the current situation and any likely developments.

Dam operators can only provide information as to timing and volume of dam outflow; predictions as to river heights or inundation areas are the responsibility of others within the disaster management framework. (See chapter *3 Disaster frameworks, preparation and planning* for a description of the different responsibilities of entities in the disaster management framework.) It is the responsibility of residents close to the dam to apprise themselves of how certain outflows will affect their property.

Different floods call for different frequency of communication.[79] A slow rising flood may require less frequent provision of information, while a rapid rise in flows may require very regular communication. It would be appropriate for emergency action plans to contain guidelines to staff at dams about the frequency of warnings that will be appropriate in different situations. One way of doing that might be to link frequency of warning with rate of rise of the lake level.

The use of SMS and/or email warnings allows large numbers of people to be contacted simultaneously. The Commission considers that this type of bulk communication would work well for those who do not require immediate notification, leaving operational staff at the dam free to contact personally those in need of urgent

notification, such as residents immediately downstream. As to the limitations of SMS warnings see *4.1.1 Warnings mechanisms (SMS alerts)*.

Recommendations

4.16 Dam operators should plan to contact people identified by their emergency action plans about dam outflow in sufficient time for them to be able to respond to the information.

4.17 Dam operators should ensure each emergency action plan includes a clear statement as to the frequency of, and circumstances in which, warnings will be issued to people listed in the emergency action plan.

4.18 Dam operators should assess the effectiveness of using SMS and/or email as a bulk instantaneous communication to all people on the notification list while individually contacting those whom it is essential to inform immediately.

Clear warnings procedures

While most dams have a single document (the emergency action plan) dealing with communications procedures during emergencies, others have multiple documents. The communication procedures for Wivenhoe Dam are included in the emergency action plan, the Wivenhoe manual,[80] the Draft Communication Protocol of the Communication of Flooding Information for the Brisbane River catchment – including Floodwater Releases from Wivenhoe and Somerset Dams,[81] and the verbal agreement with the Mid Brisbane River Irrigators,[82] discussed above. The Commission endorses the continuing review of the content of the draft communication protocol.

Seqwater intends to make those documents consistent once the draft communication protocol is finalised; however the consolidation of information into one document should be considered. Consolidation might assist both staff and recipients in the clarification of the procedures.

Care should be taken in that consolidation to ensure the nature of the Wivenhoe manual as a document to be used by the flood engineers in the operation of the dams during floods is maintained (see section *2.5 Manual of operational procedures for flood mitigation at Wivenhoe Dam and Somerset Dam* in this report). The Commission is not suggesting that the manual, emergency action plan and protocol be amalgamated. Rather, the Commission suggests that all the communication procedures are contained in only one document (probably the emergency action plan or a separate protocol). The communications procedures in the manual are brief, and do not, as currently drafted, reflect existing practice (see *2.6.10 Communications*) and could easily be removed from that document.

Recommendation

4.19 Seqwater should consider consolidating its communication arrangements and responsibilities in a single document for each dam it operates.

Community involvement and understanding

The Australian Government guidelines *Emergency Management Planning for Floods Affected by Dams*[83] indicate that the community as well as local governments and disaster management agencies should be involved in the creation of emergency management procedures, particularly in deciding who requires warnings about dam spillway outflow.[84] The involvement of local people adds to the likelihood that the warning process will be useful and effective.

Dam operators should give community members the opportunity to request to be on the warning list about dam outflow, and consider the best option for warning those people. Not all requests must be accepted; dam operators should only be responsible for warning residents if the available warning times to those residents are less than those available through the emergency management system.[85] It is not necessary for each person who is accepted as needing such a warning to be contacted personally by phone; operators can take advantage of SMS, email and social media to provide warnings to relevant sections of the community.

Further, it is important that the communication procedures, once set, are known to all involved. All people on the list in the emergency action plan should be able to obtain information on the arrangements for communication with them. This will allow them to plan effectively as well as prevent unnecessary calls for information to dam operators during a flood emergency.

Recommendations

4.20 The operator of each dam should, upon request, provide to any person on the notification list in the emergency action plan an explanation of the arrangements as to the type and frequency of communications required by that plan.

4.21 Operators of dams should assess their current compliance with the DERM *Queensland Dam Safety Management Guidelines* (February 2002), the ANCOLD *Guidelines on Dam Safety Management* (August 2003), and the Australian Government *Emergency Management Planning for Floods Affected by Dams* (2009) and if appropriate, comply with those guidelines.

4.22 Operators should include in their emergency action plan a description of the type of information that will be provided to those on the notification list.

4.23 Operators of dams should publicise, in a newspaper circulating in the local area and by posting a notice on its website every year before the wet season, the opportunity for local residents immediately downstream of a dam to be included on the existing notification list, and:

- consider whether an applicant for notification is so close to the dam that the warning time before water from the dam affects them is less than that available through the emergency management system
- consider whether they can be effectively notified by SMS or email
- if it is necessary to contact the applicant personally, agree with him or her a mode for that communication.

4.24 The operator of any referable dam and the local disaster management group should develop a common understanding as to their respective roles in a flood event and the type and frequency of information the dam operator will provide to it and local residents.

4.1.5 Information about road conditions

Queensland has over 33 000 kilometres of state-controlled roads which are managed by the Department of Transport and Main Roads.[86] During the 2010/2011 floods some roads were inundated and had to be closed.

The Department of Transport and Main Roads has clear guidelines on closing roads. These were in place before the 2010/011 wet season.[87] The department also has guidelines on how road closures should be reported on its website.[88]

The road closure process involves the following steps:

- the road is assessed by transport department officers or police officers
- after consulting others including the transport department's website operators, local police and affected residents, the officer closes the road or imposes conditions on access
- road access information is submitted to the transport department and, following an approval process, the road condition is published on the transport department's website.[89]

This process is also used when the roads are reopened.[90]

Distribution of road condition information

Information about road conditions is provided through the transport department's website or the department's call centre. Staff at regional transport department offices were available 24 hours a day, seven days a week during the 2010/2011 floods to provide information to the department's call centre.[91]

The ABC provides information about road conditions for the whole of Queensland and distributes this information via radio broadcasts and updates on local news websites. The ABC obtains its information from the transport department's webpage, local councils, the RACQ and Queensland Police.[92]

The RACQ provides information about road conditions in regional Queensland only and distributes this information via its website and an interactive voice response telephone line.[93] The RACQ's sole source of information about road condition information is the transport department.[94] The RACQ does not provide information about road conditions in south-east Queensland; this is the responsibility of the transport department.[95]

Difficulties in distributing road condition information

Website problems

The transport department's website experienced unprecedented usage[96] during the 2010/2011 floods:

- in a nine day period from 22 to 30 December 2010, there were 358 000 website visits, which was more than the number of visits for the entire 2009/2010 wet season
- during the same nine day period, the daily average was 51 000 visits, compared to the 2010 non wet season daily average of 2441 visits
- 497 000 visits were registered on one day alone (Tuesday 11 January 2011).[97]

On 28 December 2010, the website slowed considerably as a result of the increased use. The Department of Transport and Main Roads responded by using a 'splash page' of road condition information in simple text format instead of the page with maps embedded, because the graphics took longer to load and use. After 31 December 2010, the department made available maps that could be downloaded, rather than having maps embedded in the website.[98]

The RACQ website also experienced a dramatic increase in use during the 2010/2011 floods and became extremely slow. Delays in responding to telephone calls also led to an increase in the number of abandoned phone calls to the RACQ. To address this, RACQ called in staff from leave, enhanced the interactive phone line system and increased the internet server capacity from two to five servers.[99]

Delays in providing information

The timeliness and accuracy of road condition information to the public varied significantly during the 2010/2011 floods. This was caused by a range of factors:

- Roads in remote areas were more difficult to access, resulting in reports on conditions being delayed.[100]
- The swiftness of the rise and fall of water across road surfaces meant reports were often quickly out of date. This particularly affected RACQ's ability to keep up to date with conditions, as it relies on information from the Department of Transport and Main Roads.
- Not everyone in regional and remote areas was able to access information on the internet or mobile telephone, either because of remoteness or because of the effect of the floods.
- There were also delays when the Department of Transport and Main Roads webpage, which contains detailed maps and pictures showing road closures, slowed because of the number of people accessing the site. The Department switched to the 'splash page' described above to overcome this problem.

Localised information

Some residents were confused by road condition information because they knew their local roads by colloquial names which were not used on the transport department webpage.[101] This was a particular problem when the transport department's website was changed to a text only site. This confusion was somewhat alleviated after 31 December 2011 when maps became available to download.[102]

Effect on road users

As a result of inaccurate or tardy information, some road users were significantly delayed or forced to take sizeable detours after relying on road condition information.[103] Holiday travellers were affected because flooding occurred over the Christmas and New Year holiday.

Some road users were stranded in communities such as Warwick and Gin Gin, causing strain on local resources and evacuation centres.[104]

The Department of Transport and Main Roads and RACQ have both taken steps since the 2010/2011 floods to enhance the information they can provide to road users including:

- the addition of state-wide summaries of major road conditions and heavy vehicle access restriction advice on the transport department website[105]
- automating updates of the RACQ website using information from the transport department website [106]
- streamlining call centre options between the transport department and RACQ.[107]

Councils are also liaising with the transport department to overcome the difficulties they encountered with lack of timely or accurate information about road conditions.[108]

Recommendations

4.25 The Department of Transport and Main Roads, in its capacity as the primary provider of information about road conditions to the public, should continue to improve the accuracy of road condition information and the timeliness of its distribution to the public and other agencies.

4.26 The Department of Transport and Main Roads should identify and include local road names when reporting road conditions.

Cross border/interstate information

During the 2010/2011 floods, drivers in New South Wales had difficulty accessing information about flooded roads.

There are agreements regarding the exchange of road condition information between the Queensland and New South Wales governments which are intended to ensure that information about road conditions is shared between the Queensland Department of Transport and Main Roads and the New South Wales Roads and Traffic Authority. One of these agreements ensures that the Department of Transport and Main Roads in the Darling Downs region provides the New South Wales Roads and Traffic Authority with daily reports on road conditions.[109]

However, despite this arrangement, drivers in New South Wales could not easily obtain information from the radio or tourist information centres about the road conditions in Queensland.[110] Although this information was available on the internet, not all travellers could gain access to it.

In some instances, travellers relied on information from fellow road users or local police who had recently used the road ahead.[111]

Lack of road condition information led to drivers who had entered the state from the south becoming being stranded in Warwick. Approximately 280 interstate travellers had to be accommodated in evacuation centres.[112] As a result, signs were placed further south, in Stanthorpe, to warn people of road conditions ahead.[113]

Strategies that were suggested for regional and remote roads included:

- using signs that inform road users of road conditions far ahead, where detours are difficult or impossible
- using tourist information centres to provide road conditions to travellers with face to face or on noticeboards after-hours
- using tourist radio stations to transmit road conditions.

Recommendations

4.27 The Queensland Government should work with the New South Wales Government to co-ordinate road condition reporting procedures to inform local councils and road users of interstate road conditions in a variety of different ways.

4.28 In rural and remote areas where telecommunications are not effective, measures that do not rely on internet and mobile telephone services should be implemented to inform the travelling public of road conditions ahead, for example:

- signs with detailed information
- providing tourist information centres and tourist radio stations with information on road conditions.

4.2 Warnings and forecasts: Bureau of Meteorology and councils

4.2.1 How the Bureau provides information

The Bureau of Meteorology issues weather warnings on its website, and also distributes them to disaster and emergency management organisations, state and local government agencies, water agencies and media. As well as giving warnings, the Bureau provides information and advice to state and local governments and emergency services.

During the 2010/2011 floods, the Bureau gave briefings to the state disaster co-ordination centre, the state disaster management group and emergency services agencies. It also provided advice to a number of local governments, the Seqwater flood operations centre, and Sunwater. During December 2010 and January 2011, the Bureau's website was accessed over 9.4 billion times and Bureau staff took part in numerous interviews for television and radio.

4.2.2 The Bureau's warnings

Under section 6 (1)(c) of the *Meteorology Act 1955* (Cth), one of the functions of the Bureau of Meteorology is to issue warnings of weather conditions likely to give rise to floods; a function which on any rational reading must extend to warnings of weather conditions likely to give rise to flash floods, particularly those likely to endanger life or property. Sections 6 (1)(d) and (h) of the Act require the Bureau to give meteorological advice and information. Its functions are to be performed in the public interest (section 6 (2)). They are not necessarily discharged by the giving of generalised weather warnings.

4.2.3 Severe weather warnings

The Bureau issues severe weather warnings by reference to 15 districts across the state, the descriptions of which do not always make it clear what areas they encompass. By way of example, on 9 and 10 January 2011, severe weather warnings were issued 'for heavy rainfall leading to localised flash flooding and potentially worsening the existing river flood situation For [sic] people in the Southeast Coast district, southern parts of the Wide Bay and Burnett district and eastern parts of the Darling Downs and Granite Belt district'.[114] For Lockyer Valley residents to recognise the significance of such warnings for them, they had to appreciate that the Bureau regarded the Lockyer Valley as incorporated in the 'Southeast Coast district'; something not necessarily obvious to people living a considerable distance from the coastline. None of the severe weather warnings over those days was any more specific. Nor did the language of the warnings change as the situation in Toowoomba and the Lockyer Valley worsened dramatically on 10 January.

The Bureau's website, which contains maps of river systems and forecast districts, radar imagery, and images depicting the location of severe weather and thunderstorms, can assist individuals and businesses in determining whether severe weather or floods are likely to affect them. However, the site's multimedia formats provide no assistance to those listening to warnings issued by radio, without access to a computer.

4.2.4 Flood warnings

The Bureau issues flood warnings for river systems or catchments. The warnings contain information about actual and predicted river heights at certain gauges and whether further rises are predicted, and give a description of flooding in terms of minor, moderate or major flooding. Warnings may also contain information about river heights at significant road crossing or bridges and references to recent or historically significant past floods.[115] So, for example, on 11 January 2011 the Bureau issued a warning comparing the flooding expected in the Brisbane and Bremer Rivers and related tributaries with the flood levels reached in 1974. The reference to 1974 helped many people in Brisbane appreciate the size of the predicted flood and the impact it might have on them.

However, as in the case of severe weather warnings, it can be difficult to identify the particular areas to which a flood warning relates. Between 9 and 11 January, warnings issued for the middle and lower Brisbane River referred to flooding at Savages Crossing and Mt Crosby, giving river heights there. People living on or near the middle stretch of the river, including those living at Fernvale, had to know where Savages Crossing was in relation to them, and the significance of the river height gauge reading there, in order to understand what the warning meant for them. Residents' statements make it clear that many did not. (For further discussion of warnings to Fernvale residents see *4.2.11 Warnings for Fernvale*.)

Recommendation

4.29 The Bureau of Meteorology should endeavour to make clear the areas actually covered by its warnings, and specify what may be expected in particular areas, so that the relevance and significance of any warning is obvious to residents of the area at risk.

4.2.5 Weather conditions likely to cause flash flooding

The Bureau is obliged to warn of weather conditions likely to give rise to (among other things) flash floods and to give meteorological advice and information in the public interest (see *4.2.2 The Bureau's warnings*). Those obligations may not be met by the provision of a severe weather warning in broad terms.

By way of example, see *4.2.8 Warnings for Lockyer Valley and Toowoomba*, which deals with the events of 10 January 2011, when the Bureau advised the state disaster co-ordination centre watch desk of heavy rainfall moving over the Toowoomba town area with expected flash flooding, but did not similarly inform the Toowoomba Regional Council. Its website maintained a general warning for heavy rainfall leading to localised flash flooding for a number of areas including eastern parts of the Darling Downs, without any particular reference to Toowoomba.

The Commission accepts the Bureau's contention that it has been the practice for state and local governments to manage local flash flood warning systems with advice provided by the Bureau, but does not consider that practice to be inconsistent with the recommendations made below.

Recommendations

4.30 Councils should continue to take responsibility for issuing flash flooding warnings. However, where the Bureau of Meteorology becomes aware of weather conditions likely to cause flash flooding that is likely to endanger life or property in a particular council's region, it should, performing its functions in the public interest, directly communicate that information to the relevant council.

4.31 Councils should advise the Bureau of Meteorology of any information they possess about flash flooding (or the immediate prospect of it) likely to endanger life or property in their region, and of any warnings they issue about such flash flooding. The Bureau of Meteorology should consider in each case whether any such warning should be re-published (whether as a warning emanating from the Bureau itself or as attributed to the relevant council) on the Bureau's website, or whether it should provide a link to any council warning or other information regarding flash flooding provided by councils or disaster management agencies.

4.32 Where the Bureau of Meteorology has information which leads it to anticipate flash flooding likely to endanger life or property in a specific area, it should publish a warning to that effect on its website.

4.2.6 Bureau communications with councils during 2010/2011 floods

With primary responsibility for the management of disaster events, councils need detailed and accurate information from the Bureau about weather conditions and flooding in council regions. During the 2010/2011 floods, councils could obtain weather and flood information by participating in the state disaster co-ordination centre teleconferences at which the Bureau gave briefings or by contacting the state disaster co-ordination centre watch desk. In addition, the Bureau encouraged local council engineers to contact the Bureau's flood warning centre to speak with Bureau staff directly.[116]

The Bureau distributes a variety of forms of warning by email and facsimile to those on its client list, including councils. It does not, however, communicate directly with all councils during severe weather events and flooding. During the 2010/2011 floods, there were some councils with which the Bureau conducted a mutual exchange of information, the Bureau advising river heights, and the councils advising of local weather and river conditions. For example, before and during the December 2010 flooding in the Nogoa and Comet Rivers, the Central Highlands Regional Council was in regular contact with Bureau hydrologists in relation to predicting flood levels in the region. The particular advantage of this approach was that it allowed the Bureau to take into account information about river levels from local farmers and rural residents.[117]

However, the Bureau's practice of maintaining direct contact with councils was not uniform throughout the 2010/2011 floods. According to the Bureau, it has stronger relationships with some councils than others and will actively contact the former to discuss evolving weather situations in their area. It is in the process of improving its relationships with all councils.[118] A number of councils, including Moreton Bay Regional Council and Goondiwindi Regional Council, have recently approached the Bureau to develop a closer partnership with it for weather and flood events.[119]

Recommendation

4.33 The Bureau of Meteorology should do its best to develop working relationships with all councils, particularly for the purpose of exchanging information in severe weather and flood events.

4.2.7 Bureau communication with Ipswich City Council on 11 January 2011

On 11 January 2011, the height which the Bureau was predicting for the Bremer River rose significantly over a period of six hours. At 4.07 am on 11 January 2011, the Bureau's prediction, as it had been since the preceding afternoon, was that the river would reach a height of 12.7 metres. However, according to Anthony Trace, the local disaster co-ordinator, at 8.00 am on 11 January the local disaster management group learned from the Bureau's website that the predicted height was 14.7 metres; and an hour and a half later, at 9.28 am the Bureau issued a fresh warning that the Bremer River would reach 16 metres, with higher levels expected. On his account, he confirmed by a telephone call to the Bureau at 2.00 pm that afternoon that the prediction remained unchanged at 16 metres, and duly reported that information to a meeting of the local disaster management group. The difference between 12.7 metres and 16 metres was significant in terms of the impact the flooding would have on the city, and what response was required and possible.

At 3.00 pm, however, the Bureau's website showed an expected flood height of 18 to 19 metres, and when Mr Trace rang to enquire about it, he was informed that the prediction was now for a level of 22 metres. That information was confirmed in an official warning issued at 3.24 pm. The Bureau's advices over the following evening and the next day predicted river heights of between 20.5 and 22 metres; in fact the Bremer River peaked at 19.4 metres at 1.00 pm on 12 January. The Bureau's failure to provide warnings between 9.28 am and 3.24 pm was, Mr Trace said, a cause of some concern.

However, the sequence of Bureau warnings and predictions which Mr Trace describes does not accord with the Bureau's account. At an 11.00 am briefing of the state disaster co-ordination centre, Peter Baddiley, the Bureau's regional hydrology manager, advised that the Bremer River was likely to reach 18 metres. The Ipswich City Council did not participate in this briefing, although the Ipswich district disaster co-ordinator was present.[120] The Bureau's

call log shows attempts by the flood warning centre to ring Mr Trace's mobile telephone at 11.40 am, and then a call received, apparently from that mobile number, at 11.50 am. Mr Baddiley and another Bureau hydrologist, James Stuart, took part in a conversation lasting almost nine minutes, of which both made brief notes. In it, they advised that the Bremer River would reach 18 metres that night, with further rises the following day. The caller advised that the council's response plans were based on the Bureau's prediction plus one metre. Asked what message the council would want the Bureau to give about the situation in any radio broadcast, the caller asked that they direct Ipswich residents to the council's website and advise them that if they lived close to a stream, they should self-evacuate. All of that, Mr Trace agreed when he gave evidence, accurately reflected the council's approach. However, he said, he did not make any such call, and its contents did not come to his attention. Mr Trace's mobile telephone records were made available to the Commission; they show no call made at the relevant time.

The Commission has no reason to doubt the evidence of either Mr Baddiley or Mr Trace. Mr Baddiley and his fellow hydrologist plainly spoke to someone from the Ipswich City Council and advised him of the expected river height of 18 metres. It is inconceivable that if Mr Trace had received that information, he would not have passed it on to the local disaster management group; but it is clear that when the group met at 2.00 pm that afternoon he was still under the impression that the river would not rise above 16 metres. The only possible conclusion is that another officer from the council spoke to the two hydrologists and failed to pass the information on to Mr Trace. The problem was compounded when Mr Trace, ringing the Bureau at 2.00 pm, was given to understand that the river height prediction remained unchanged. It seems entirely possible that he and whomever he spoke to in the call (which was extremely brief: 43 seconds) were at cross purposes about what predicted height was being confirmed.

The Commission does not see any benefit in further inquiry into the matter. The end result of what occurred is that the local disaster management group operated for some three hours under a misapprehension that the predicted river height level was significantly lower than the actual prediction. The confusion would have been avoided had the Bureau's hydrologists followed their advice up by email confirmation; but given the demands made on them by the events of the day, it is not surprising that they did not. The episode underlines the importance of agencies operating during a disaster keeping clear records of significant information received and given, which is immediately accessible to those who need to use it or need to know what has been conveyed.

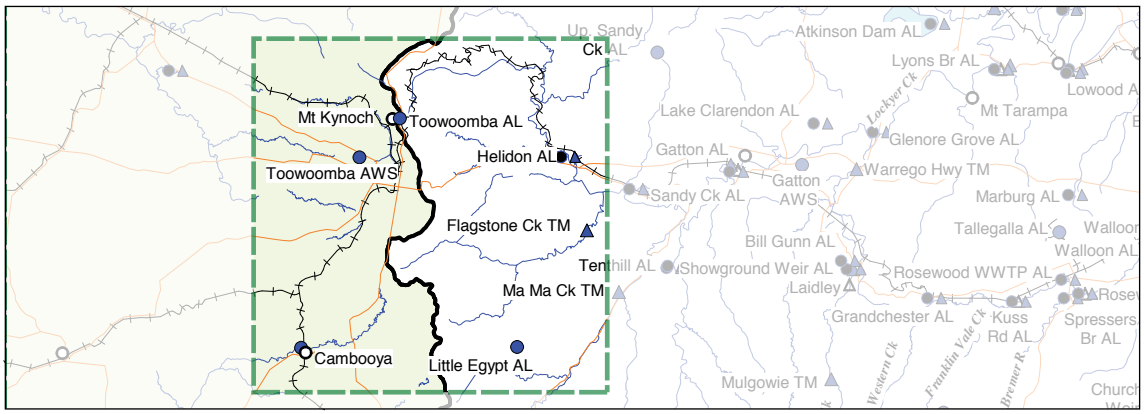
4.2.8 Warnings for Lockyer Valley and Toowoomba

The Bureau of Meteorology provides the Toowoomba Regional Council (by email), and the Lockyer Valley Regional Council (by email and facsimile) with a number of types of warnings, including, in both cases, severe weather warnings and flood warning summaries. The Toowoomba council is also sent severe thunderstorm warnings, while the Lockyer Valley council is provided with three-hourly river height bulletins for the Brisbane River and its tributaries (which include Lockyer Creek).[121]

Weather data from Toowoomba

The weather warnings which the Bureau issues in Toowoomba reflect real time rainfall data received from two stations in the Toowoomba area. The Bureau's AWS (an automatic weather station that monitors temperature, humidity, wind speed, pressure and rainfall) is situated at the Toowoomba Airport. Seqwater operates an ALERT station (reporting rainfall continuously via VHF radio) near Mt Kynoch, about six kilometres north of Toowoomba. Both stations are located outside the catchments of creeks upstream of Toowoomba's central business district.

Figure 4(a) Location of Toowoomba stations



(Source: Bureau of Meteorology, Map 143.1)

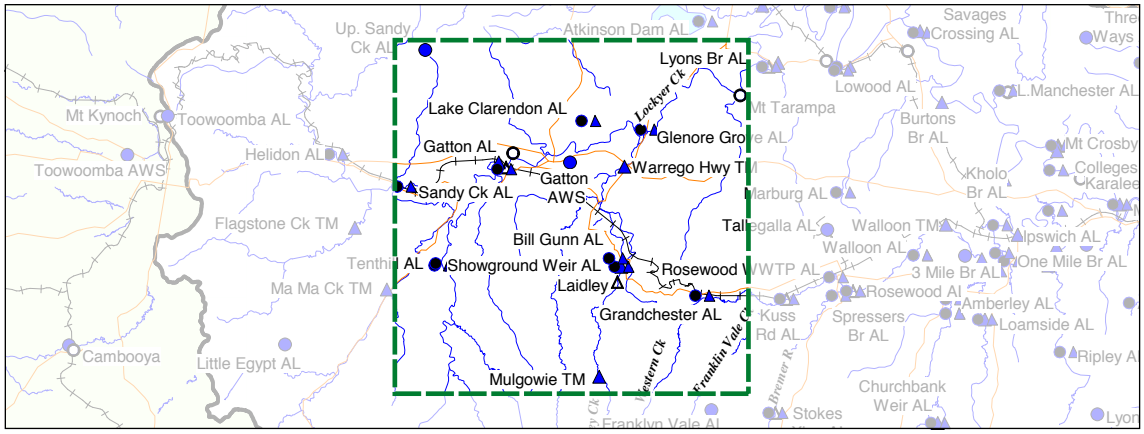
In addition to these two stations, the Toowoomba Regional Council manages a rain gauge network across Toowoomba's central business district and surrounding suburbs. Rainfall data from these stations, however, are not provided to the Bureau during rain-flood events.[122]

Weather data from the Lockyer Valley region

The Bureau of Meteorology provides information about flood conditions in the Lockyer Creek system in the course of issuing flood warnings for the Brisbane River basin. Warnings are issued if a key river height station in a major Brisbane River tributary, including the Lockyer Creek, exceeds a moderate flood level.

The warnings for the Lockyer Valley region reflect river height and rainfall data received from river height and rainfall gauges across the Valley, including ALERT and telemeter stations on the Lockyer Creek at Helidon; manual, ALERT and telemeter stations on the Lockyer Creek at Gatton; and ALERT gauges at Upper Sandy Creek and Sandy Creek Road near Grantham. DERM owns the telemeter station at Helidon, Seqwater owns the ALERT station at Helidon and both stations at Gatton, and the Lockyer Valley Regional Council owns the Upper Sandy Creek and Sandy Creek Road gauges. The Bureau has real time access to all of these gauges during a weather event. It does not monitor them to detect flash floods, but rather uses the data obtained to forecast flows in the lower catchment. Its automatic systems collect and publish river height data from the gauges on its website every 15 minutes, with maps, tables and plots updated every 30 minutes.[123] DERM also operates a water level station at Spring Bluff; but the Bureau says that it holds no data from it for the flood events of the December 2010/January 2011 period.[124]

Figure 4(b) Location of Lockyer Valley stations



(Source: Bureau of Meteorology, Map 143.1)

Community sources of information

The Bureau operates a network of 'storm spotters' who can report to it if they observe or hear of a severe thunderstorm in their local areas. They are registered with the Bureau and can provide their information by using a freecall phone number or by lodging a report electronically or by post.[125] There are nine registered 'storm spotters' in the Toowoomba Lockyer Valley region. The Bureau says that it also maintains volunteer rainfall and river height networks at many locations.[126] However, as is explored further in *4.2.9 Helidon gauge spike*, it appears that those networks are by no means comprehensive in their coverage.

Warnings in the period leading up to 10 January

The Bureau of Meteorology issued flood warnings referring to the Lockyer Valley four times on 5 December 2010 and six times between 19 and 22 December. At 12.45 pm on 23 December 2010, a severe weather warning was issued for 'rainfall with locally moderate to heavy falls and the potential for flooding' over a broad area of Queensland from the Gulf of Carpentaria to south-east Queensland; incorporating, without specifying, the Lockyer Valley in its reference to south-east Queensland. The warning was re-issued every six hours until 28 December 2010. At 7.57 pm on 26 December 2010, a 'Priority Flood Warning' was issued, which included mention of Lockyer Creek. Specific flood warnings for the Lockyer Creek were then issued between 27 December and 30 December 2010.[127]

From 5 January 2011, the Bureau issued severe weather warnings for the south-east coast district (which the Bureau, as already mentioned, regards as including the Lockyer Valley). Those warnings identified the threat of heavy rain and thunderstorms which could lead to localised flash flooding or worsen existing river flooding. On 9 January, four such warnings were issued, at 4.40 am, 10.55 am, 4.55 pm and 11.00 pm. The last three extended the warning to the eastern Darling Downs. [128] In addition, Bureau staff gave interviews to radio, including Toowoomba-based radio stations, newspaper and online media.[129]

Warnings for Lockyer Valley and Toowoomba on 10 January 2011

On 10 January 2011 the Bureau issued warnings relevant to the Toowoomba region and the Lockyer Valley as set out in the table below.[130]

Figure 4(c)
Warnings issued on 10 January 2011 for Toowoomba and the Lockyer Valley

Date	Time of issue	Warning header
10 January 2011		
	12:36 am	FLOOD WARNING FOR THE LOWER BRISBANE BELOW WIVENHOE Issues at 12:36 AM on Monday the 10th of January 2011
	5:00 am	SEVERE WEATHER WARNING for heavy rainfall leading to localised flash flooding and potentially worsening the existing river flood situation For people in the Southeast Coast district, southern parts of the Wide Bay and Burnett district and eastern parts of the Darling Downs and Granite Belt district. Issued at 5:00 am on Monday 10 January 2011
	9:19 am	FLOOD WARNING FOR COASTAL STREAMS FROM MARYBOROUGH TO THE NSW BORDER Issued at 9:19 AM on Monday the 10th of January 2011
	10:28 am	FLOOD WARNING FOR THE LOCKYER, BREMER, WARRILL AND BRISBANE RIVER BELOW WIVENHOE Issued at 10:28 AM on Monday the 10th of January 2011
	11:00 am	SEVERE WEATHER WARNING for heavy rainfall leading to localised flash flooding and potentially worsening the existing river flood situation for people in the Southeast Coast district, southern parts of Wide Bay and Burnett district and eastern parts of the Darling Downs and Granite Belt district. Issued at 11:00 am on Monday 10 January 2011

Date	Time of issue	Warning header
	11:05 am	SEVERE WEATHER WARNING for heavy rainfall leading to localised flash flooding and potentially worsening the existing worsening the existing river flood situation for people in the Southeast Coast district, southern parts of Wide Bay and Burnett district and eastern parts of the Darling Downs and Granite Belt district. Issued at 11:00 am on Monday 10 January 2011(Re-issued to amend update time)
	11:40 am	Flood summary Issued at 11:40 AM on Monday the 10th of January 2011
	4:16 pm	FLOOD WARNING FOR THE LOCKYER, BREMER, WARRILL AND BRISBANE RIVER BELOW WIVENHOE INCLUDING BRISBANE CITY Issued at 4:16 PM on Monday the 10th of January 2011
	5:00 pm	FLASH FLOOD WARNING FOR LOCKYER CREEK Issued at 5:00 PM on Monday the 10th of January 2011
	5:05 pm	SEVERE WEATHER WARNING for heavy rainfall leading to localised flash flooding and potentially worsening the existing river flood situation For people in the Southeast Coast district, far southern parts of the Wide Bay and Burnett district and eastern parts of the Darling Downs and Granite Belt district. Issued at 5:05 pm on Monday 10 January 2011
	6:12 pm	FLOOD WARNING FOR THE LOCKYER, BREMER, WARRILL AND BRISBANE RIVER BELOW WIVENHOE INCLUDING BRISBANE CITY Issued at 6:12 PM on Monday the 10th of January 2011
	6:30 pm	SEVERE WEATHER WARNING for heavy rainfall leading to localised flash flooding and potentially worsening the existing river flood situation. For people in the Southeast Coast, Darling Downs and Granite Belt and eastern parts of the Maranoa and Warrego districts. Issued at 6:30 pm on Monday 10 January 2011
	7:50 pm	SEVERE WEATHER WARNING for heavy rainfall leading to localised flash flooding and potentially worsening the existing river flood situation For people in the Southeast Coast, Darling Downs and Granite Belt, far southern parts of the Wide Bay and Burnett and eastern parts of the Maranoa and Warrego districts. Issued at 7:50 pm on Monday 10 January 2011
	8:37 pm	FLASH FLOOD WARNING FOR LOCKYER CREEK Issued at 8:37 PM on Monday the 10th of January 2011
	9:44 pm	FLOOD WARNING FOR THE LOCKYER, BREMER, WARRILL AND BRISBANE RIVER BELOW WIVENHOE INCLUDING BRISBANE CITY Issued at 9:44 PM on Monday the 10th of January 2011
	11:00 pm	SEVERE WEATHER WARNING for heavy rainfall leading to localised flash flooding and potentially worsening the existing river flood situation For people in the Southeast Coast, Darling Downs and Granite Belt, far southern parts of the Wide Bay and Burnett and eastern parts of the Maranoa and Warrego districts. Issued at 11:00 pm on Monday 10 January 2011

As noted already, such warnings are provided to the Toowoomba and Lockyer Valley councils by email or facsimile; but the Bureau was not in direct communication with either council, the Toowoomba disaster district co-ordinator or the Emergency Management Queensland office based in Toowoomba. It was expected that the district co-ordinator would become aware of material information through state disaster co-ordination centre teleconferences and state disaster management group meetings and would telephone the Bureau for additional advice if required.[131]

Bureau warning to the state disaster co-ordination centre about Toowoomba

Between 11.00 am and 11.40 am on 10 January 2011, a meteorologist and hydrologist from the Bureau took part in a teleconference with the state disaster co-ordination centre. During it, they brought to the attention of those conferring the existing severe weather warning which included the prospect of flash flooding. At 11.55 am, a Bureau

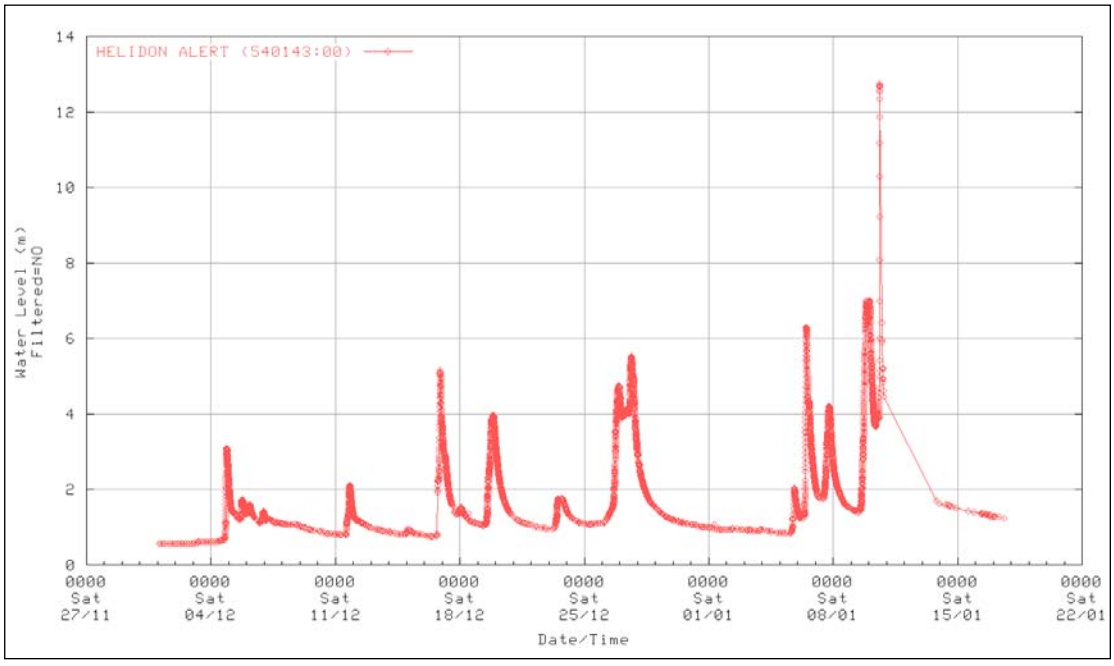
meteorologist telephoned the state disaster co-ordination centre watch desk to warn of a severe thunderstorm for the Darling Downs and further north.[132]

At 1.00 pm on 10 January, a Bureau meteorologist again contacted the state disaster co-ordination centre to advise of extremely heavy rainfall moving over the Toowoomba town area with expected flash flooding in the next hour or two, which could result in calls for assistance. He advised, too, that a Bureau 'storm spotter' had reported very heavy rainfall in the Cressbrook Dam area. The Bureau did not update its website, considering that the existing severe weather warning for eastern parts of the Darling Downs covered the situation.[133] Nor did it contact the Toowoomba Regional Council to provide it with the same advice.

It would have been desirable for the Bureau to have directly communicated this warning to the Toowoomba Regional Council. However, the Commission accepts the evidence of Ken Gouldthorp, chief executive officer of Toowoomba Regional Council, that it was unlikely such a warning would have enabled the local disaster management group to respond any more quickly or effectively to the events which unfolded.

4.2.9 Helidon gauge spike

Water level rises commenced at the Lockyer Creek at Helidon at approximately 2.20 pm on 10 January 2011. At 2.50 pm the Helidon TM gauge gave its highest reading of 12.66 metres; no further reports were received. The other gauge at this location, the Helidon AL gauge, gave its highest reading at 2.53 pm of 12.74 metres and then several readings which made it seem (erroneously) that it had peaked at this level, before ceasing to report for approximately two and a half hours. (Both gauges had failed because of inundation. DERM subsequently surveyed the creek and estimated the flood peak at 13.88 metres, occurring at approximately 3.10 pm. That was more than six metres higher than the level recorded in the 1974 flood.) The Bureau's 3.30 pm river height bulletin gave the latest available levels at Helidon as 12.66 metres R (for rising) at 2.50 pm and 12.68 metres at 3.02 pm.[134]



Water levels for Lockyer Creek at Helidon AL during 9 to 11 January 2011. (Date/time is EST)[135]

Water level readings at Helidon became available in the Bureau's computer system at around 3.00 pm or shortly after. According to the Bureau, only a few of the readings were then available; the computer had automatically marked most of the readings, which were incomplete, from the Helidon AL station as incorrect.[136] However, it appears that readings for Helidon appeared on the Bureau's website at about 3.00 pm and were read with a mixture of concern and disbelief by some residents of Grantham who were paying attention to the site.[137]

The Bureau contends that those readings that had been received had the characteristics of a faulty station; and there was no flood warning rainfall or water level network above the Helidon gauge to enable it to assess with any accuracy the water levels at Helidon.[138] No member of the public or of emergency services organisations had given

it any advice of flash flooding at Helidon, Murphy's Creek, Postman's Ridge or Withcott. Its attention was focussed on potential flooding in the Brisbane and Bremer Rivers. Staff of the Bureau's flood warning centre did not become aware of the readings until between 4.00 pm and 4.30 pm, and did not appreciate their significance until they saw television footage at 4.30 pm of the flash flood in Toowoomba. They then took steps to verify them, with the result that the Bureau issued a flash flood warning for the Lockyer Creek at 5.00 pm on 10 January. By that time, of course, the flood peak had already passed through Grantham; the warning advised of 'very fast and dangerous rises possible downstream at Gatton'.

While it is unfortunate that the Bureau did not immediately recognise the readings and their implications for downstream residents, the Commission accepts that the Bureau's resources are not such as to permit full-time monitoring of gauge results. Although the radar imagery suggested heavy rainfall, the Bureau did not have the benefit of other gauge information in the upper Lockyer catchment area to confirm the radar readings. The rainfall gauge at Helidon itself did not give any remarkable results: 11 millimetres between 1.00 pm and 2.00 pm. The spike in the Helidon river height gauges occurred extremely suddenly (a rise of at least eight metres in less than an hour) and without warning. The Bureau received only one 'on the ground' report from the region on 10 January 2011; from a storm spotter relaying weather information about the area of the Cressbrook Dam.[139] No-one actually in the vicinity of the Lockyer Creek or other waterways in the Lockyer Valley alerted it to the rapid rise in local streams.

It seems extraordinary – and a very great pity – that the Bureau, and other agencies, were oblivious to what was actually happening in Helidon that afternoon. But in the absence of evidence that there was anything to alert the Bureau earlier to the abnormal gauge readings, it should not be criticised for failing to recognise the readings and their significance sooner than it did. It should be said, too, that even if a timely warning about the prospect of flash flooding downstream had been given, it is unlikely, given the complete absence of any precedent, that anyone would have anticipated that the Lockyer Creek would break its banks and produce the massive wave which engulfed Grantham.

The Bureau says that it maintains volunteer rainfall and river height networks. It is clear, though, from its contentions as to why it was unaware of what was occurring at Helidon, that it had no volunteers in the Lockyer Valley to inform it of events there or at Murphys Creek, Postman's Ridge, or Withcott, which might have put it on alert for abnormal rises in the Lockyer Creek. Automated systems are extremely useful, but their existence should not lead to disregard of the value of human observation and local knowledge.

Flooding in the Lockyer Creek at Helidon, 10 January 2011 (photo courtesy Martin Thomas)

Recommendation

4.34 The Bureau of Meteorology should expand its volunteer rainfall and river height networks to incorporate residents of the Lockyer Valley, particularly property owners living on watercourses who can provide manually obtained readings of water heights where no automatic gauge is available, or can confirm automatic gauge readings where there is concern about their accuracy.

4.2.10 Amateur weather watchers

On 10 January 2011 individuals posting on a publicly available Weatherzone website made observations about a severe weather event in the Toowoomba Lockyer Valley region.[140] In postings respectively at 12.16 pm and 1.10 pm they expressed concerns about probable torrential rainfall in the Gatton-Grantham area and the possibility of a dangerous flash flood, particularly in Grantham (although the watercourse identified as of concern was Sandy Creek, rather than the Lockyer Creek).

Those individuals did not fit into the Bureau's characterisation of storm spotters; their interest was in analysis of weather events, rather than in reporting observations of thunderstorms. Unsurprisingly, then, they were not registered in the storm spotter network. Had they tried to contact the Bureau as members of the public, they would have had to ring its exchange number and were likely to have their call placed in a queue, with the uncertain prospect, depending on caller volume, of being able to speak to a member of staff.[141]

Recommendation

4.35 The Bureau of Meteorology should consider identifying amateur weather-watch groups it considers credible and likely to have useful local knowledge, and establish means (similar to those available to the storm spotters) by which they can expeditiously communicate with the Bureau.

4.2.11 Warnings for Fernvale

Situated approximately eight kilometres from the Wivenhoe Dam, Fernvale experienced its first flood peak on the morning of 11 January 2011. Local water courses rose quickly; some Fernvale residents were forced onto the roofs of their homes to escape the rapidly rising waters.[142]

Later, on the evening of 11 January 2011, the Fernvale area flooded once more. Again, the speed of the rising water caught many residents unaware. In some cases, the water rose so quickly that residents had to wade through waist-high water that was not present more than five or six minutes earlier.[143] Residents were forced to higher ground to escape the flood waters, often staying with friends or relatives nearby.

The evidence of Fernvale residents suggests that they received very limited warnings about flooding. This was despite residents using internet, radio, television and social media to try to obtain meaningful information for Fernvale.[144] The Bureau publishes predictions for the height of the Brisbane River at the Lowood and Savages Crossing gauges, both of which are located in the Brisbane River and near the Fernvale community. However, the Fernvale area also contains many smaller streams and creeks. According to the Bureau, the Lowood and Savages Crossing gauges may not help to predict flooding in the Fernvale area when the flooding is caused by localised rainfall and/or rises in local streams and creeks, and not the Brisbane River.[145]

The Commission draws no conclusions about the causes of the flooding in Fernvale during the January 2011 floods.

The prediction of flooding in Fernvale may require consideration of any releases from the nearby Wivenhoe Dam. The Bureau's regional hydrology manager stated that the Somerset Regional Council would need to consult with the Bureau and the dam operator (Seqwater) to determine how best to provide accurate flood level predictions for Fernvale residents.[146]

Once the consultation process has occurred, the Bureau may be able to post river height and creek height levels specific to the Fernvale area on its website. However, it will remain the responsibility of the Somerset Regional Council to advise residents whether increasing flood levels are likely to result in inundation to their properties.

Recommendation

4.36 Somerset Regional Council, in consultation with Seqwater and the Bureau of Meteorology, should consider how warnings can be provided to residents living near the Brisbane River at Fernvale about the expected level of flooding in their area.

(Endnotes)

1 Section 6 (1)(c), *Meteorology Act 1955* (Cth).

2 Submission of Telstra Corporation Limited [p1: para 2]; Submission of the State of Queensland, Department of Community Safety, 11 March 2011 [p5]; Second Submission of the State of Queensland, Department of Community Safety, 4 April 2011 [p3].

3 Submission of State of Queensland, Department of Community Safety, 11 March 2011 [p5].

4 Transcript, Kerry Plowright, 6 May 2011, Brisbane [p1432: line 56]; Exhibit 297, Statement of Kerry Plowright [p2].

5 Transcript, Councillor Peter Maguire, 25 May 2011, Emerald [p2589: line 48]; Exhibit 478, Statement of Councillor Peter Maguire [p2: para 1(h)]; Exhibit 123, Statement of Philip Berting [p8]; Exhibit 229, Goondiwindi Regional Council local disaster management group Debrief Meeting 31 January 2011 [p7]; Transcript, Senior Sergeant Simon Chase, 20 April 2011, Dalby [p740: line 52]; Transcript, Inspector Terry Kajewski, 20 April 2011, Dalby [p755: line 19; p760: line 15].

6 Submission of the State of Queensland, Department of Community Safety, 11 March 2011, DCS-10, Annexure F, Appendix 3, [p5].

7 Transcript, Craig Hewlett, 6 May 2011, Brisbane [p1420: line 1]; Exhibit 295, Statement of Craig Hewlett, 19 April 2011 [p2: para 7]; Transcript, Superintendent Patrick Ryan, 9 May 2011, Brisbane [p1497: line 40]; Exhibit 307, Statement of Superintendent Patrick Ryan, 8 March 2011 [p6-7]; Transcript, Sergeant Jason Renwick, 9 May 2011, Brisbane [p1503: line 1].

8 Transcript, Jennifer Beattie, 20 May 2011, Ipswich [p2328: line 23]; Exhibit 438, Statement of Jennifer Beattie, 12 May 2011 [p4: para 12].

9 Transcript, Anthony Martini, 9 May 2011, Brisbane [p1527: line 18].

10 Transcript, Anthony Martini, 9 May 2011, Brisbane [p1538: line 1]; Exhibit 307, Minutes of Redcliffe District Disaster Management Group Extraordinary Meeting 2011 Flood Debrief, 3 February 2011 [p3]; Transcript, Anthony Trace, 20 May 2011, Ipswich [p2389: line 9].

11 Transcript, Peter Hackney, 9 May 2011, Brisbane [p1514: line 1]; Exhibit 381, Statement of Kate Girot, 18 April 2011 [p4: para 22]; Transcript, Gail Nixon, 24 May 2011, Emerald [p2571: line 4]; Transcript, Councillor Peter Maguire, 25 May 2011, Emerald [p2589: line 57].

12 Second Submission of the State of Queensland, Department of Community Safety, 4 April 2011 [p4].

13 Transcript, Anthony Martini, 9 May 2011, Brisbane [p1524: line 55]; Exhibit 445, Statement of Anthony Trace, 6 April 2011 [p49: para 186].

14 Submission of the State of Queensland, Department of Community Safety, 11 March 2011 [p5].

15 Second Submission of the State of Queensland, Department of Community Safety, 4 April 2011 [p4].

16 Transcript, Bruce Grady, 26 May 2011, Brisbane [p2673: line 12].

17 Transcript, Superintendent Patrick Ryan, 9 May 2011, Brisbane [p1497: line 24]; Transcript, Anthony Martini, 9 May 2011, Brisbane [p1526: line 4]; Transcript, Anthony Jacobs, 9 May 2011, Brisbane [p1596: line 57].

18 Transcript, Superintendent Patrick Ryan, 9 May 2011, Brisbane [p1497: line 47]; Exhibit 307, Minutes of Redcliffe District Disaster Management Group Extraordinary Meeting 2011 Flood Debrief, 3 February 2011 [p2].

19 Transcript, Sergeant Jason Renwick, 9 May 2011, Brisbane [p1503: line 18]; Exhibit 308, Statement of Sergeant Jason Renwick, 15 April 2011 [p4: para 11]; Transcript, Craig Hewlett, 6 May 2011, Brisbane [p1420: line 19]; Exhibit

295, Statement of Craig Hewlett, 19 April 2011 [p2: line 8].

20 Transcript, Cr Peter Maguire, 25 May 2011, Emerald [p2590: line 56].

21 Exhibit 297, Statement of Kerry Plowright, 29 April 2011 [p7].

22 Submission of the State of Queensland, Department of Community Safety, 11 March 2011 [p5].

23 Transcript, David Greenwood, 20 May 2011, Ipswich [p2355: line 23]; Exhibit 443, Statement of David Greenwood, 8 April 2011 [p2].

24 Transcript, Andrew Solomon, 5 May 2011, Brisbane [p1315: line 31]; Exhibit 227, Statement of Andrew Solomon, 29 April 2011 [p4: para 12]; Transcript, Bruce Flegg, 5 May 2011, Brisbane [p1353: line 51]; Exhibit 295, Statement of Craig Hewlett, 19 April 2011 [p2: para 4; p3: para 9]; Exhibit 443, Statement of David Greenwood, 8 April 2011 [p2].

25 Transcript, Craig Hewlett, 6 May 2011, Brisbane [p1420: line 1]; Transcript, David Greenwood, 20 May 2011, Ipswich [p2358: line 30].

26 Transcript, Ray Brown, 20 April 2011, Dalby [p802: line 2]; Transcript, Graeme Scheu, 3 May 2011, Goondiwindi [p1206: line 44]; Exhibit 481, Statement of William Wilkinson, undated, [p14: para 9(o)].

27 Exhibit 481, Statement of William Wilkinson, undated, [p14: para 9(o)].

28 Transcript, Collin Head, 23 May 2011, Rockhampton [p2488: line 39]; Exhibit 463, Statement of Collin Head, 5 April 2011 [p23: line 17(b)].

29 Transcript, Graeme Scheu, Goondiwindi, 3 May 2011 [p1205: line 20]; Transcript, Inspector David Peff, 23 May 2011, Rockhampton [p2440: line 52]; Transcript, Bruce Grady, 26 May 2011, Brisbane [p2660: line 15]; Exhibit 302, Statement of Peter Martin, 3 May 2011 [p12: para 50]; Exhibit 506, Independent Review of Brisbane City Council's Response to the January 2011 Flood [p35].

30 Exhibit 506, Independent Review of Brisbane City Council's Response to the January 2011 Flood [p35].

31 Exhibit 312, Statement of Anthony Martini, 8 May 2011 [p9: para 61]; Transcript, Rod Ferguson, 3 May 2011, Goondiwindi [p1219: line 5]; Exhibit 258, Stanthorpe Sub-Group Incident Control Centre Debrief [p9].

32 Exhibit 370, Statement of Greg Hoffman with letter dated 5 April 2011 [p9: para 4].

33 Transcript, Ray Brown, Dalby, 20 April 2011 [p802: line 21].

34 Transcript, Graeme Scheu, 3 May 2011, Goondiwindi [p1205: line 33]; Exhibit 229, Goondiwindi Regional Council Local Disaster Management Debrief Meeting, 31 January 2011 [p7].

35 Exhibit 302, Statement of Peter Martin, 3 May 2011 [p12: para 50].

36 Transcript, Daniel McCoombs, 9 May 2011, Brisbane [p1547: line 50]; Exhibit 381, Statement of Kate Girot, 18 April 2011 [p4: para 24]; Transcript, Dennis Ward, 6 May 2011, Brisbane [p1459: line 3]; Exhibit 300, Statement of Denis Ward, 8 April 2011 [p15: para 107]; Submission of Timothy Grevell; Submission of Sharon Claridge-Mohr; Submission of Joan and Howard Smith.

37 Transcript, Rod Ferguson, 3 May 2011, Goondiwindi [p1221: line 16].

38 Transcript, Sergeant Benjamin Wiltshire, 20 April 2011, Dalby [p724: line 57]; Exhibit 114, Statement of Sergeant Benjamin Wiltshire, 12 April 2011 [p3: para 30].

39 Transcript, Greg Hoffman, 13 May 2011, Brisbane [p1987: line 54]; Exhibit 336, Statement of Stuart Holley, 9 May 2011 [p9].

40 Transcript, Stuart Holley, 11 May 2011, [p1721: line 8]; Transcript, Anthony Martini, 9 May 2011, Brisbane [p1537: line 17]; Exhibit 312, Statement of Anthony Martini, 8 May 2011 [p2: para 8]; Exhibit 334, Statement of Mark Holmes, 25 March 2011 [p4: para 7; p7: para 9]; Transcript, Philip Berting, 20 April 2011, Dalby [p788: line 56].

41 Transcript, Sean Hodgson, 6 May 2011, Brisbane [p1430: line 30].

42 Transcript, Sean Hodgson, 6 May 2011, Brisbane [p1430: line 37].

43 Transcript, Sergeant James Kelly, Emerald, 24 May 2011 [p2524: line 1].

44 Exhibit 474, Statement of Councillor Gail Nixon, 17 May 2011 [p4: para 22].

45 Transcript, Councillor Gail Nixon, 24 May 2011, Emerald [p2571: line 27].

46 Transcript, Glen Taylor, 20 April 2011, Dalby [p694: line 22].

47 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p6: para 40].

48 Exhibit 497, Statement of Peter Baddiley, 11 May 2011 [p8-9: para 28].

49 Exhibit 497, Statement of Peter Baddiley, 11 May 2011 [p8: para 28].

50 Transcript, James Davidson, 13 April 2011, Brisbane [p266: line 10].

51 Transcript, Cleave Rogan, 4 May 2011, St George, [p1240: line 28]; Transcript, Donald Whalley, 6 May 2011, Brisbane [p1414: line 52]; Transcript, Anthony Jacobs, 9 May 2011, Brisbane [p1597: line 56]; Transcript, Collin Head, 23 May 2011, Rockhampton, [p2484: line 44; 2486: line 4]; Exhibit 463, Statement of Collin Head, 5 April 2011 [p13: para 9(a)]; Transcript, Vaughn Becker, 23 May 2011, Rockhampton, [p2512: line 46]; Transcript, Sergeant James Kelly, 24 May 2011, Emerald, [p2533: line 2; Transcript, Gail Nixon, 24 May 2011, Emerald, [p2568: line 40]; Transcript, Desmond Howard, 24 May 2011, Emerald, [p2538: line 25]; Transcript, William Wilkinson, 25 May 2011, Emerald [p2627: line 45].

52 Transcript, William Wilkinson, 25 May 2011, Emerald [p2624: line 48].

53 Exhibit 497, Statement of Peter Baddiley, 11 May 2011 [p10-11: paras 35, 38].

54 Transcript, Peter Baddiley, 27 May 2011, Brisbane [p2702: line 33].

55 Transcript, Councillor Gail Nixon, 24 May 2011, Emerald [p2568: line 40]; Transcript, William Wilkinson, 25 May 2011, Emerald [p2627: line 51].

56 Transcript, Juleia Murray, 6 May 2011, Brisbane [p1480: line 19]; Exhibit 304, Statement of Juleia Murray, 22 April 2011 [p2: para 7].

57 Transcript, Andrew Young, 5 May 2011, Brisbane [p1371: line 25]; Transcript, Michael Baker, 6 May 2011, Brisbane [p1409: line 46]; Exhibit 444, Statement of Paul Tully, Attachment 1, 27 April 2011 [p2]; Exhibit 370, Statement of Greg Hoffman with letter dated 5 April 2011 [p8].

58 Exhibit 292, Statement of Michael Baker, Attachment 1, 6 April 2011 [p2].

59 Exhibit 481, Statement of William Wilkinson, undated [p4: para 2(f)].

60 Transcript, Megan McKillop, 6 May 2011, Brisbane, [p1482: line 8]; Transcript, Paul Tully, 20 May 2011, Ipswich [p2362: line 8]; Exhibit 444, Statement of Paul Tully, 27 April 2011, Attachment 1 [p1]; Exhibit 370, Statement of Greg Hoffman with letter dated 5 April 2011 [p8].

61 Transcript, Anthony Trace, 20 May 2011, Ipswich [p2386: line 1].

62 Exhibit 446, Supplementary statement of Anthony Trace, 19 May 2011 [p72: paras 271-272].

63 Exhibit 506, Independent Review of Brisbane City Council's Response to the January 2011 Flood [p36]; Exhibit 404, Statement of Kenneth Morris, 3 May 2011 [p10: para 2.2]; Submission of Brisbane City Council [p12: para 5.7(c), (d)].

64 Transcript, Kenneth Morris, 17 May 2011, Brisbane [p2155: line 31]; Exhibit 404, Statement of Kenneth Morris, 3 May 2011 [p15: para 3.10].

65 Exhibit 404, Statement of Kenneth Morris, 3 May 2011 [p14: para 3.9].

66 Exhibit 270, Statement of Scott Norman, 1 April 2011 [p10: para 19(c)]; Transcript, Collin Head, 23 May 2011, Rockhampton [p2492: line 8]; Exhibit 463, Statement of Collin Head, 5 April 2011 [p25: para 19(a)]; Transcript, Councillor Peter Maguire, 25 May 2011, Emerald [p2595: line 53]; Exhibit 311, Statement of Anthony Martini, 4 May 2011 [p27]; Transcript, Rod Ferguson, 3 May 2011, Goondiwindi [p1218: line 29]; Exhibit 249, Statement of Rod Ferguson, 14 April 2011 [p6: paras 59-60]; Transcript, Anthony Jacobs, 10 May 2011, Brisbane [p1607: line 18].

67 State Planning Instruments Program 1 July 2010 to 30 June 2011, http://www.dlgp.qld.gov.au/resources/spi-program-2010-2011.pdf.

68 Sections 341 and 346, *Water Supply (Safety and Reliability) Act 2008* (Qld).

69 Exhibit 507, Emergency Action Plan – E J Beardmore Dam, January 2008; Exhibit 508,

Emergency Action Plan – Leslie Dam, January 2008; Exhibit 509, Emergency Action Plan – Coolmunda Dam, January 2008; Exhibit 510, Emergency Action Plan – Glenlyon Dam, September 2006; Exhibit 511, Emergency Action Plan – Callide Dam, January 2008; Exhibit 512, Emergency Action Plan – Kroombit Dam, January 2008; Exhibit 513, Emergency Action Plan – Fairbairn Dam, January 2008; Exhibit 426, Attachment 4 – Emergency Action Plan for Wivenhoe Dam, September 2010; Exhibit 314, North Pine Dam Emergency Action Plan, September 2010; Exhibit 502, Statement of James Grayson, Attachment JRG-04 Awoonga Dam Emergency Action Plan, November 2010; Somerset Dam Emergency Action Plan, September 2010.

70 Transcript, Councillor Peter Maguire 25 May 2011, Emerald [p2595: line 11].

71 Transcript, William Wilkinson 25 May 2011, Emerald [p2617: line 21].

72 Statement of Robert Keogh, 1 June 2011 [p27].

73 Statement of Robert Keogh, 1 June 2011 [p27].

74 Exhibit 501, Statement of Robert Keogh, 27 May 2011, Schedule 10 [p22-23], Schedule 15 [p20-22], Schedule 17 [p16-17], Schedule 21 [p14-15].

75 Statement of Robert Keogh, 1 June 2011, Attachment RKG-04, Australian Government publication *Emergency Management Planning for Floods Affected by Dams* [p18].

76 Transcript, 15 April 2011, Brisbane, [p423: line 5]; Exhibit 428, Statement of Graham Keegan, 31 March 2011.

77 Exhibit 422, Statement of Kenneth Schmidt, 5 April 2011 [p9: para 32]; Transcript, Darren Zanow, 15 April 2011, Brisbane, [p429: line 31].

78 Statement of Robert Keogh, 1 June 2011, Attachment RKG-03 [p39-40].

79 Statement of Robert Keogh, 1 June 2011, [p17-18].

80 Exhibit 21, Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam, Revision 7, 2009 [p15-16].

81 Exhibit 417, Statement of Barry Dennien, 5 April 2011, Annexure D.

82 Exhibit 422, Statement of Kenneth Schmidt, 5 April 2011, Annexure 2 [p12].

83 Statement of Robert Keogh, 1 June 2011, Attachment RKG-04, Australian Government, *Emergency Management Planning for Floods Affected by Dams*.

84 Statement of Robert Keogh, 1 June 2011, Attachment RKG-04, Australian Government, *Emergency Management Planning for Floods Affected by Dams* [p8, 10, 13, 14, 18].

85 Statement of Robert Keogh, 1 June 2011, Attachment RKG-04, Australian Government, *Emergency Management Planning for Floods Affected by Dams* [p18].

86 Statement of David Stewart, 18 April 2011 [p6].

87 Statement of David Stewart, 18 April 2011 [p2: para 8].

88 Statement of David Stewart, 18 April 2011 [p2: para 9].

89 Statement of David Stewart, 18 April 2011 [p4: para 23].

90 Statement of David Stewart, 18 April 2011 [p4].

91 Statement of David Stewart, 18 April 2011 [p5].

92 Statement of John McClelland, 29 April 2011 [p10].

93 Correspondence from RACQ received by the Commission, 15 April 2011 [p1].

94 Correspondence from RACQ received by the Commission, 15 April 2011 [p2].

95 Correspondence from RACQ received by the Commission, 15 April 2011 [p1].

96 Statement of David Stewart, 18 April 2011 [p3].

97 Statement of David Stewart, 18 April 2011 [p3].

98 Statement of David Stewart, 18 April 2011 [p3].

99 Correspondence from RACQ received by the Commission, 15 April 2011 [p2].

100 Statement of David Stewart, 18 April 2011 [p5].

101 Transcript, Betty Mickelbrough, 4 May 2011, St George [p1250: line 4].

102 Statement of David Stewart, 18 April 2011 [p4].

103 Queensland Flood Commission of Inquiry Regional Meeting Notes – Chinchilla, Condamine, Surat, Rolleston, Gayndah and Gin Gin; Statement of Mr John Ryall, 4 April 2011 [p2: para 7].

104 Queensland Flood Commission of Inquiry Regional Meeting Notes – Gin Gin; Statement of

Mr Rod Ferguson. 14 April 2011 [p6: para 52]; Statement of Collin Head, 5 April 2011 [p14: para (d)]; Statement of Councillor Gail Nixon, 17 May 2011 [p6: para 36].

105 Statement of David Stewart, 18 April 2011 [p4].

106 Correspondence from RACQ received by the Commission, 15 April 2011 [p2].

107 Correspondence from RACQ received by the Commission, 15 April 2011 [p2].

108 Transcript, Colin Head, 23 May 2011, Rockhampton [p2487: line 1].

109 Statement of David Stewart, 18 April 2011 [p6].

110 Exhibit 218, Statement of John Ryall, 4 April 2011 [p3].

111 Exhibit 218, Statement of John Ryall, 4 April 2011 [p3].

112 Transcript, Rod Ferguson, 3 May 2011, Goondiwindi [p1216: line 42].

113 Transcript, Rod Ferguson, 3 May 2011, Goondiwindi [p1217: line 9].

114 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p29: para 113].

115 Exhibit 494, Statement of Peter Baddiley [p17: para 60].

116 Exhibit 496, Statement of Peter Baddiley [p14: para 51].

117 Transcript, Maguire, 25 May 2011, Emerald [p2594: line 29]; Transcript, Wilkinson, 25 May 2011, Emerald [p2612: line 15-35; p2613: line 27; p2614: line 22].

118 Transcript, James Davidson, 18 April 2011, Toowoomba [p549: line 46; p550: line 14].

119 Transcript, Councillor William Kearney, 3 May 2011, Goondiwindi [p1173: line 27]; Transcript, Anthony Martini, 9 May 2011, Brisbane [p1522: line 13].

120 Transcript, Anthony Trace, 20 May 2011, Ipswich [p2407: line 36].

121 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p37-38].

122 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p51].

123 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [pp 44-45].

124 Exhibit 38, Provision of Preliminary Meteorological and Hydrological Information: Background briefing for the QFCI, February 2011 [p11].

125 Transcript, James Davidson, 18 April 2011, Toowoomba [p554: line 10].

126 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p55].

127 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p39].

128 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011, Annexure I-12, Table 7 [p701].

129 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p53].

130 Exhibit 38, Provision of Preliminary Meteorological and Hydrological Information; Background briefing for the QFCI, February 2011 [p25-27].

131 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p34].

132 Transcript, James Davidson, 18 April 2011, Toowoomba, [p541: line 27].

133 Transcript, James Davidson, 18 April 2011, Toowoomba, [p542: line 1].

134 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p43-45].

135 Exhibit 38, Bureau of Meteorology Preliminary Meteorological and Hydrological Information; Background briefing for the QFCI, February 2011 Figure 3.4.2.3, [p15].

136 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p45].

137 Exhibit 153, Statement of Bronwyn Darlington, 20 January 2011 [p5: paras 30-31]; Exhibit 179, Statement of Daniel Watkins, 30 January 2011 [p5-6: paras 28-30].

138 Exhibit 37, Statement of James Davidson, Annexure JD-1 Bureau of Meteorology Report to Queensland Floods Commission of Inquiry, March 2011 [p44-45].

139 Transcript, James Davidson, 18 April 2011, Toowoomba [p554: line 23].

140 Exhibit 68, Queensland Flood Commission Report – Submission of Anthony Cornelius, undated.

141 Transcript, James Davidson, 18 April 2011, Toowoomba [p555: line 15].

142 Exhibit 300, Statement of Dennis Ward, 8 April 2011 [p8: para 56].

143 Exhibit 382, Statement of Angela Newhnam, 15 April 2011 [p8: paras 60 and 61], Exhibit 319, Statement of Janet Carpenter, 15 April 2011 [p6: paras 37 and 38].

144 Statement of Janet Carpenter, 15 April 2011 [p4: paras 21-22]; Transcript, Janet Carpenter, 9 May 2011, Brisbane [p1575: line 54].

145 Exhibit 497, Statement of Peter Baddiley, 11 May 2011 [p23: para 86].

146 Transcript, Peter Baddiley, 27 May 2011 [p2724: line 9].