Naturally, the residential areas that are severely inundated during this 2.5% event are identified at intolerable risk, while the open space and rural land to the west is identified at generally acceptable risk. This is because the residential area presents a higher and therefore less tolerable risk than the nearby open space. While the open space golf course may be severely inundated in parts, the risk to life, property and infrastructure is minimal in comparison to the residential area.

While not currently built upon, there are significant tracts of urban residential and mixed use zoned land that are exposed to the flood hazard. A high level urban land supply analysis could be undertaken to provide an initial understanding of the amount of land subject to flood hazard that could be developed based on the underlying zonings assigned to each lot, and the reconfiguration potential of those lots prescribed by the town planning scheme.

4.6 Setting a resilience target

Once the level of flood risk for areas or properties was completed, a resilience target was set as a ‘goal’ to strive for when examining and preparing flood risk management measures. This target (such as percentage of urban area affected by flood) can be used as a metric to quantify the effect of those measures used to address the flood risk, when considered against the current situation.

In line with the principles of NERAG, the broad intention is to set a resilience target that is lower than the current level of resilience, so that the amount of area affected by flood is reduced to as low as reasonably practicable.

Setting a resilience target ensures that what is sought to be achieved by flood risk treatment measures is clear and definable; it provides an easily understandable objective to assess the appropriateness or usefulness of a certain measure (or suite of measures) in achieving that target.

Other possible resilience targets could be:

- Eliminating or reducing the number of lots subject to intolerable flood risk, where the priority is treating the highest level of risk only;
- Eliminating or reducing the flood risk to transport linkages between critical infrastructure (such as evacuation centres/airports) and the balance of urban areas where such a risk exists; and/or
- Reducing the number of lots subject to tolerable flood risk, to ensure these lots are then subject to broadly acceptable risk.

Finalisation of the resilience target recommended for adoption will be presented in the following Preliminary Flood Risk Management Plan that will accompany this Study.

5 Risk Management Measures

Following from the 2005 NSW Government's Floodplain Development Manual, addressing flood risk is now generally based on addressing risk management measures based on three broad categories:

Flood modification measures modify the flood's physical behaviour (depth, velocity and direction of flow paths) and include flood mitigation dams, retarding basins and levees.

Response modification measures modify the community's response to flood hazard by educating flood affected property owners about the nature of flooding so that they can make informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

Property modification measures modify land use and development controls. This is generally accomplished through such means as flood proofing (house raising or sealing entrances), strategic planning (such as land use zoning), building regulations (such as flood-related development controls), or voluntary purchase.

A fundamental principle of good flood risk management is that management measures should not be considered either individually or in isolation. They should be considered collectively so that their interactions, their suitability and effectiveness, and their social, ecological, environmental and economic impacts can be assessed on a broad basis.

The Blackall Flood Risk Management Plan needs to consider all three types of management measures and adopt an integrated and effective mix that is appropriate to the specific circumstances of the flood prone community. The options suggested to form part of the Floodplain Management Plan are summarised in Table 14 following the discussion. These options should be read as a total package of consideration rather than isolated solutions.

The management measures discussed were developed in co-operation with the Key Stakeholder Group as identified by BTRC as representatives of the Blackall community.

5.1 Measures Not Considered Further

5.1.1 Flood Mitigation Dams

Dams, even if full, can significantly reduce downstream flood discharges. As the flood wave passes through a dam, the dam is progressively filled to the point of overflow, and then provides temporary storage above the spillway crest level for floodwaters subsequently passing through the dam. The ability of a dam to mitigate floods depends largely on the surface area of the dam at spillway level and its spillway capacity. The larger the surface area and the smaller the spillway capacity, the greater the reduction in downstream discharges. This effect is most beneficial immediately downstream of the dam and the benefits reduce as the flood wave travels downstream.

Most dams are 'multi-purpose', i.e. they provide water for irrigation and domestic use, as well as providing flood mitigation potential. Generally, constructing a dam purely for flood control cannot be justified economically. The mitigating effects of even large dams on severe floods is often surprisingly small because:

- the surface area of the dam at spillway level is relatively small and the spillway capacity is large;
- the volume of water in a severe flood may be much greater than the storage capacity of even a large dam; and
- floods may result from rainfall in parts of the catchment that are not commanded by dams. Consequently, the benefits of flood mitigation dams are generally limited to mitigating the effects of a flood generated in only one portion of the catchment.

Dams are extremely expensive to construct, require an appropriate and large location, can have a significant adverse effect on the local environment and have a residual risk if the dam fails or the floods exceed dam capacity.

Accordingly, a flood mitigation dam was not considered further as part of this study.

5.1.2 Voluntary Building Purchase Scheme

Under a voluntary purchase scheme, Council would offer to purchase flood liable properties if and when they became available for purchase, subject to the availability of funds at the time. Voluntary purchase is not compulsory acquisition and affected property owners can expect to receive market values for their property.

In certain high-hazard areas, it may be impractical or uneconomic to mitigate flood hazard to existing properties at risk. In such circumstances, it may be appropriate to cease occupation of such properties to free residents and potential rescuers from the hazard of future floods. Purchasing properties and removing or demolishing buildings can achieve this. Such areas should ultimately be rezoned to a flood-compatible use, such as recreation or parkland.

However, special treatment may be required if the property is constrained by orders such as a Heritage Listing and suitable uses may have to be determined for these properties that satisfy the general objectives of the Flood Risk Management Plan.

In consideration of a voluntary purchase scheme, it is relevant to understand the social and economic costs of flooding on those in areas of high flood impact to ascertain whether this measure provides the optimum flood risk management solution.

Voluntary purchase schemes may be pre-empted by a change of zoning or strategic intent in the new planning scheme, but this may cause angst as it could be considered to devalue a property to unfairly affect the purchase price in favour of the council.

5.1.3 Voluntary Building Raising

Voluntary building raising (houses in particular) has long been a traditional response to flooding.

Homeowners generally have very strong sentimental and emotional attachments to their dwellings, which generally represent a large capital investment. Avoiding flood damage by house raising, which in essence is another form of flood proofing, achieves the important objectives of:

- reducing personal loss;
- reducing risk to life and limb;
- reducing costs of servicing isolated people who remain in their homes during floods to protect possessions; and
- reducing stress and post-flood trauma.

In general, house raising is a suitable mitigation measure only for low hazard areas of the floodplain. In high hazard areas, structural means of protection are generally required, or voluntary purchase.

Not all houses are suitable for raising. Houses of single or double brick construction or slab-on-ground construction are generally either impossible or too expensive to raise. Houses best suited to raising are timber framed and clad with non-masonry materials.

Based on the previous house-raising schemes implemented after the April 1990 floods in Blackall that resulted in 19 houses being raised and 6 houses relocated, it is considered an additional scheme would be unable to be economically justified given the age and small number of homes that would require raising.

Accordingly, it is recommended that a Voluntary Building Raising Scheme does not form part of a Flood Risk Management Plan for Blackall.

5.2 Flood Modification Measures

Flood modification measures are designed to modify the behaviour of the flood itself, by reducing flood levels or velocities, or excluding floodwaters from areas under threat. This includes:

- dams (not considered further - see 5.1.1);
- levees, flood gates, pumps;
- detention / retarding basins;
- channel modifications; and
- bypass floodways.

Discussion on each of these measures is provided in the following sections.

5.2.1 Levees, Flood Gates & Pumps

Permanent or temporary levees are built to exclude previously inundated areas from flooding or inundation from the riverine and overland flow up to a certain design event. They are commonly used on large river systems but can also be found on small creeks in urban areas.

A permanent levee is a well-designed constructed barrier that in Australia is often built from compacted soil but can also incorporate a floodwall on top (i.e. the Warrego Levee located in Charleville where a floodwall was added to an existing earthen levee).

Temporary levees are, as the description suggests, not permanent structures to be built, but are instead a mobile flood barrier solution deployed in advance of an impending flood event and often comprise of modular panels that are linked together to create a physical barrier. Another common mobile flood barrier design is what is known as a ‘flood sausage’ - flexible PVC tubing (often twin, side-by-side tubes) that are initially inflated with air while awaiting deployment and then filled with water in their final position - used to also create a barrier.

Levees are generally the most economically attractive measure to protect existing development in flood-liable areas. The height or crest level of a levee is determined by a variety of factors including the economics of the situation (including the nature of development requiring protection), physical limitations of the site, and the height to which floods can rise relative to the ground levels in the area (important for safety considerations).

A levee may rarely be called upon to achieve its design requirements. If it fails at this time because of poor design, improper construction or lack of maintenance, the money spent on its construction has largely been wasted.

Even if design, construction and maintenance have been exemplary, all levees will ultimately be overtopped unless designed for the PMF event. Even if designed for PMF events, levees can still fail through lack of maintenance, inadequate construction or unforeseen circumstances. Thus, it is not a question of ‘if’ the overtopping of a levee will occur, but of ‘when’, and of the consequences.

With mobile flood barriers, for these to be effective their final position of their placement is paramount and a decision about this placement may not be easily made during the beginnings of a flood event unless a ‘defensive line’ strategy is adopted.

Hence, the importance of flood emergency plans that address the defence and evacuation of areas protected by levees.

In using levees for flood mitigation, some precautions need to be noted:

- The likelihood of catastrophic damage and unacceptable hazard levels when the levee is overtopped. When, in April 1990, rising flood waters breached the emergency sandbag levees at Nyngan, NSW, hazardous conditions rapidly developed within the protected area, lives were at risk (although there were no fatalities) and the resulting damage and disruption cost over $50 million.

Provision of spillways to enable the controlled overtopping of the levees to avoid uncontrolled high velocity overflows or even breaching when the levee is overtopped.

Proper maintenance of the levee crest level, grass cover and spillways, and avoiding damage by traffic or animals.

Flood emergency plans for levee overtopping and evacuation. The need for such plans is particularly important where escape routes can be severed (e.g. a ring levee) or where the protected area can fill rapidly once overtopping commences (e.g. Nyngan).

Analysis of flow conditions that may develop inside the protected area when overtopping occurs and the flood continues to rise. In some situations, high-hazard conditions can develop within protected areas, particularly around breaches in the levee, the occurrence and location of which cannot be predicted.

On-going community education to ensure the population is aware of the risk of overtopping, is informed about flood emergency plans, and does not lapse into the common belief that levees 'provide total protection against all floods'.

Levees have the potential to increase flood levels elsewhere on the floodplain. This aspect needs to be addressed when formulating any levee proposal.

Careful consideration needs to be given to draining local runoff water that collects within the protected area. It may be necessary to install pumps and sumps to remove this water during floods. If the pumps fail, 'internal' flooding may occur.

For mobile flood barriers, storage and maintenance testing will be very important, as it is easy for these devices to be neglected whilst in storage.

Mobile flood barriers requiring considerable organisation and labour for them to be deployed. This time and effort will need to be at the expense of other activities undertaken in the lead up to a flood event. Practise of deployments will be required.

Some of these precautions do not all apply when the PMF is adopted as the defined event for levees. In such cases, important factors to consider include proper maintenance of the levee and provision of adequate 'freeboard' against wave action and subsidence.

Despite their problems, levees are a common, important and effective management measure for existing flood problems. However, at best they are a partial solution and should be supplemented by comprehensive flood emergency measures.

It may be possible to construct a permanent levee along the northern bank of the Barcoo River to a maximum probable flood level. A levee built to maximum probable flood level would almost eliminate the risk of overtopping and consequential outcomes from such an event. However, it may not be physically possible to build the levee to such a height on land available between the commercial section of town and the river. Nonetheless, building a levee to this level should not be discarded at this point.

In terms of the material used to construct such a levee, it is likely suitable sources of material will be available in the vicinity of the proposed levee. It is known that loam exists along the riverbanks of the Barcoo River close to the town of Blackall. This loam is not generally considered to be suitable, however, a blend of loam and black soil may be suitable. However, blending material together and carting from borrow pits to the levee alignment may be financially prohibitive, particularly for a levee built to a maximum probable flood level.

Floodgates would be required to release water from the Ticklebelly Gully back into the river, however, a rainfall and runoff analysis could be undertaken to establish the height of the water stored against a levee crossing Ticklebelly Gully. The results of this rainfall and runoff analysis may mean that a few properties are affected by the level of water within the protective area of the levee from local runoff. Stormwater backflow devices may also be required to stop water backing up the stormwater drainage line leading from Banks Park and also the southern end of Clematis Street south of Shamrock Street.

Table 12: Key Features of Levee Systems

ISSUE	COMMENT
Advantages:	
"Environmentally Sensitive Measure"	A well-designed vegetated earthen embankment set back far enough from the bank to retain access, and that does not interrupt local drainage, can have minimal environmental impact. However, in many locations it is hard to meet all these criteria.
Protects a large number of buildings	A levee system could protect a large number of buildings from being inundated up to the 100 year ARI or even larger flood event.
Low maintenance cost	A levee system needs to be inspected annually for erosion or failure. In addition, there is ongoing weekly or monthly maintenance (grass cutting, vegetation trimming). The annual cost of inspections for erosion or failure (of say floodgates) will generally be small (say less than $10 000 per annum per levee). However this amount can vary considerably depending upon the complexity and size of the structure
Disadvantages:	
High cost	The cost to import fill, compact and construct an earthen levee is dependent on the availability of good quality fill and the associated transport costs, these will vary depending upon the locality. However, generally it is the land take and associated costs (possible services re-location and access) which add considerably to the cost. For these reasons, no detailed costings have been undertaken at this stage. It is likely that levees will cost several million dollars depending upon their size and location but may be the only viable mitigation measure.
Low to medium benefit cost ratio	Whilst the levee system may protect a large number of buildings from being inundated in a (say) 100 year event it is likely to have a low to medium benefit cost ratio as there are few building floors inundated (and so being able to be protected) in the more frequent floods (less than a 10 year ARI event).
Local runoff from within the "protected area" or upstream may cause inundation	The ponding of local runoff from within the "protected area" may produce levels similar to that from the flood itself. At present local runoff already causes problems in several areas. Constructing a levee will compound this problem. It can be addressed by the installation of pumps or flap valves on pipes but these add to the cost and the risk of failure.
May create a false sense of security	Unless the levee system is constructed to above the PMF level, it will be overtopped. When this occurs the damages are likely to be higher as the population will be much less flood aware (as happened in New Orleans, USA in August 2005).
Relaxation of flood related planning controls	Most residents consider that following construction of a levee the existing flood related planning controls (minimum floor level, structural integrity certificate) should be relaxed. However, many experts consider that this should not be the case unless the levee is built to the PMF level and the risk of failure is nil. The general opinion is that a levee should reduce flood damages to existing development but should not be used as a means of protecting new buildings through a reduction in existing standards.
Restricted access to the water	Access to the water for boating and other activities requiring easy access will be restricted. This can be addressed by (expensive) re-design of entry points.

Floodgates allow local runoff to be drained from an area (say an area protected by a levee) when the external level is low, but when the river is elevated, the gates prevent floodwaters from the river entering the area (they are commonly installed on drainage systems within a levee area).

Pumps are generally also associated with levee designs. They are installed to remove local runoff behind levees when floodgates are closed or if there are no floodgates. Unless designed for the PMF, levees will be overtopped. Under overtopping conditions, the rapid inundation may produce a situation of greater hazard than exists today. This may be further exacerbated if the community is under the false sense of security that the levee has "solved" the flood problem (as happened with Hurricane Katrina in New Orleans, USA).

Pumps have been suggested as a means of addressing the "internal drainage" problem but are not widely used in levee type situations in Queensland. Some of the drawbacks of employing pumps are:

- high capital cost. In many instances two sets of pumps are installed in case one set is being repaired or maintained when the flood occurs,
- high maintenance cost. The pumps have to be regularly maintained and tested by trained personnel,

relatively high risk of failure. Experience in other areas has shown that as the pumps are used only infrequently there is a relatively high risk of failure due to:

- inadequate maintenance of the pumps causing seals or valves to deteriorate,
- power cuts caused by the storm,
- failure of the device that activates the pumps.

The pumps are only required to operate for a short time (several hours) possibly once or twice a year. If they fail to start or fail during the event there is practically no likelihood that service personnel will be able to restart them prior to the peak level being reached. An alternative to pumps is to install additional flap gated culverts and these can be more cost effective though also can fail (mainly due to vandalism or vegetation “jamming” the mouth open).

Both a permanent levee and use of a mobile flood barrier as a temporary levee solution is considered a suitable option for Blackall warranting further investigation.

5.2.2 Detention Basins / Retarding Basins

A detention basin or retarding basin is a small dam that provides temporary storage for floodwaters. It behaves in the same way as a large dam, but on a much smaller scale. In urban areas, detention basins are most suitable for small streams that respond quickly to stormwater flooding.

Detention basins have a number of inherent disadvantages that should be carefully evaluated. They include:

- a substantial area of land is required to achieve the necessary storage;
- where used for multiple purposes, e.g. as playing fields as well as for flood mitigation purposes, public safety aspects during flooding need to be addressed;
- long-duration or multi-peak storms (when the basin is partly or completely filled from a previous peak) can increase the risk of overtopping, breaching and resulting downstream hazard; and
- depending on their size, detention basins may provide little attenuation of discharges when overtopping occurs.

Consequently, it is important that detention basins are properly designed, constructed and maintained and that their impact on the hazard of a range of flood events be investigated fully.

With appropriately designed outlet works, detention basins act as sediment traps thereby improving urban water quality by reducing the concentration of settable solids. There may be, however, adverse downstream effects associated with this loss of sediment. Such issues also need to be assessed when considering the impacts of detention.

Detention basins are not a viable flood modification measure when addressing the river-sourced flooding from the Barcoo in Blackall. Accordingly, detention basins are not a recommended flood modification measure for the Barcoo. However, with suitable design that takes into account flooding, social, economic and environmental issues, may be appropriate for local runoff within town. Here basins may be more appropriate when planning future urban development, in conjunction with water sensitive urban design (WSUD) measures, however it is recognised that Blackall is unlikely to experience any significant greenfield urban development in the near future that would provide the land necessary to result in significant hydraulic detention.

5.2.3 Channel Modifications

The capacity of a river channel to discharge floodwater can be increased by widening, deepening or realigning the channel, and by clearing the channel banks and bed of obstructions to flow. The effectiveness of channel improvements depends upon the characteristics of the river channel and the river catchment.

As a mitigation measure, channel improvements have several potential disadvantages. First, they facilitate the transfer of floodwaters downstream and can accentuate downstream flooding problems. Other disadvantages include the cost of maintenance, the potential to adversely impact on natural channel morphology, the destruction of riverine habitat and the visual impact of replacing naturally varying channel sections with a section of more uniform geometry.

Channel improvements are likely to be most effective (including reducing the need for other structural works) on steeper smaller streams with overgrown banks and narrow floodplains. Channel improvements would have a minimal effect in flooding situations where there are extensive areas of over bank flooding, such as at Blackall, however keeping the river channel clear of overgrowing thick vegetation will improve its hydraulic efficiency to some degree.

Accordingly, it is recommended that channel improvement works do not form part of a Flood Risk Management Plan for Blackall.

5.2.4 Bypass Floodways

Bypass floodways redirect a portion of the floodwaters away from areas at risk, and so reduce flood levels along the channel downstream of the bypass floodway off take. Bypass floodways are commonly used in conjunction with levees.

Opportunities for constructing bypass floodways are limited by the topography of the area, ecological considerations and availability of land. Bypass floodways may exacerbate flood problems along the bypass channel itself and at locations downstream of the bypass channel through facilitating downstream transfer of floodwaters.

Despite these shortcomings, bypass floodways can provide a useful management option, especially in conjunction with levees.

At the key stakeholders meeting, a bypass floodway – to the west of Blackall in the Barcoo where the topography is considered somewhat suitable and there is limited infrastructure obstructing flow – was identified as a possible flood modification measure. . This would need to consider any current and future rural residential development to the south of Blackall and adjustments to access routes for this development.

If Council desires further consideration of this measure, a bypass would need to focus on redirecting the top 300mm of the flood and bypassing the main part of the river. However, aerial photographic views show that this alignment may pass through a newly developed subdivision (Charlie Prow’s rural residential subdivision) and will also need to cross the state controlled Isisford – Blackall Road. In addition, the increased slope of the river bed over this shorter section may lead to scouring of the channel. If appropriate, stabilisation works and widening may need to be considered.

On balance, it is recommended that a bypass floodway (at least for the Barcoo) does not form part of a Flood Risk Management Plan for Blackall when taking into account the extraction of vast amounts of sand, soil and other material to create the bypass, land resumptions and road crossing cost and aesthetic considerations.

5.3 Response Modification Measures

Response Modification Measures encompass various means of modifying the response of the community to the flood threat. Such measures include flood warning, plans for the protection and evacuation of an area and for recovery after a flood. These measures do not protect people, property and infrastructure, but focus on reducing the impact of flooding on people’s lives.

Unless the Probable Maximum Flood is adopted as the design flood (which is generally impractical and prohibitively expensive), flood modification measures and property modification measures will have a residual risk from floods exceeding their design limits. The development and implementation of effective emergency response plans (flood response measures) are a means of reducing this residual flood related risk to people’s lives by making them aware and prepared to respond to flooding.

In general, response modification measures are the simplest and most cost-effective measures to install, alongside planning measures for reducing risk to future development. In fact, they may be, in some cases, the only economically justified modification measures.

5.3.1 Emergency Planning and Management

In the context of flood risk management, emergency planning and management aims to first, minimise the adverse impacts of the event(s), and second, promote recovery. There is a cost to emergency management and inevitably, therefore, there is a balance to be struck between meeting these aims and the cost and effort of the emergency management itself. It is, however, evident from past floods that effort to better prepare for a flood are highly efficient.

Loss of life and injury can be significant in major flood events. The number of injures will depend on the execution of effective emergency plans, but as a general rule the relationship between the number of fatalities and the number of people exposed during a flood event is fairly constant. Effective emergency planning and response can, however, have a significant influence on the scale of injury or loss of life.

Flood Emergency Planning
Flood emergency planning involves preparing for floods – regardless of the perceived level of protection – and planning the response during a flood emergency. One of the most important decisions is whether people should be evacuated or stay in or near their homes and businesses. The decision is based on the likely depth and duration of flooding, the warning time and the availability of local safe havens where people can stay during the flood event.

If evacuation forms part of the emergency plan, the following should be covered in the plan:

- Define the locations to where people should be evacuated (the evacuation points);
- Define the evacuation routes and ensure that these are maintained (so they are available when needed);
- Establish emergency shelters;
- Establish evacuation priorities and procedures;
- Provide information on evacuation procedures and routes to all those who will be involved with the evacuation (including organisers and communities to be evacuated);
- Provide warnings where access routes are dangerous during floods;
- Provide adequate emergency services resources (land-based crews, boats, helicopters and so on); and
- Provide adequate emergency support resources (food, water, medical supplies and so on) at the evacuation points.

Evacuation routes should:

- lead to high ground or buildings that are safe from flooding;
- not cross areas that could be flooded, for example areas of low ground; and
- avoid bridges and other crossings of watercourses that could be washed away during a flood.

Evacuation is itself a hazardous activity and is unlikely to be risk free. To limit such risks, preferential evacuation routes should be well marked and understood by the public and other stakeholders (for example along raised roadways or purposefully managed clear ways, with limited or no parking, and good signage systems), and access routes for emergency responders should be determined in advance, locating emergency equipment stores.

Even with such measures, risks can be increased if evacuation is delayed, and takes place after a flood has started to occur. For these and other reasons, in large floodplains widespread evacuation should be avoided as far as possible, and communities should over time learn to 'live with rivers', developing community based local safe havens and resilience and resistance within the floodplain. When well-structured and planned, however, evacuation has a legitimate role to play as a response modification measure.

Safe Havens / Evacuation Centres

Planning for evacuation is not the only focus of activity prior to a flood event. The provision of safe havens, allowing people to stay close (or closer) to their homes and livelihoods in the floodplain, forms an important component of any emergency plan. A safe haven (or refuge) is simply an area or building that is constructed so that it will not flood (in all plausible events), and where people can congregate safely in times of flood. It could consist of an existing building with accommodation above flood level, a raised area of ground or a new structure. The construction and workmanship must be high quality and strong enough to resist the flow of flood water that is likely to occur in the area where it is constructed.

A safe haven should normally have an alternative use during normal periods, for example as a local market or community centre. The community should be aware of the purpose of the safe haven.

In addition to community-based safe havens, significant opportunities exist to improve the resistance and resilience of existing buildings. These include preventing floodwaters entering the building (by using flood gates and the like), strengthening the structure, using materials that are not damaged by flood water, or protecting the building by external means (e.g. constructing earth embankments around houses in areas where the depths of flooding are low). Such approaches enable people to stay in their home during floods, and importantly, speed the process of recovery after the flood. Voluntary Building Protection Retrofits or flood proofing as a response modification measures is further discussed in Section 5.4.1 on page 52.

Once it is decided where people will stay during a flood (in their house, a safe haven or an emergency shelter), it is likely that people will have to stay for several days or weeks. This is because of the time it could take for a flood to recede. Buildings where people stay during floods should therefore be equipped with sufficient safe drinking water, food and other essentials.

In the lead up to an impending flood event, emergency management focus switches to response mode with attention initially on flood forecasting and warning. The response to a flood begins either when a flood warning is received or, if there is no warning, when flooding first starts to occur. The purpose of flood forecasting and warning is to provide as much advance notice as possible of an impending flood. It therefore forms a vital component of emergency planning, as implementation of an emergency plan will be triggered by flood warnings. Flood warnings as a response modification measure is further discussed in the following section - Section 5.3.2 on page 46.

Where an emergency plan exists, this should be implemented. A key decision is whether people evacuate or 'shelter in place' (in either a house or safe haven). Evacuation requires moving people from their settlement to a safe place. The organisation of the evacuation will be set out in the emergency plan. It may be either community led or led by the authorities, for example, local government. The objective of evacuation is, wherever possible, to get people to safety before the flood arrives, as evacuation during a flood is far more hazardous.

Once the decision to evacuate is made, communities must accept the authority of the evacuation organisers. Other requirements set out in the emergency plan must also be implemented, including, for example, preparing and opening emergency shelters, arrangements for emergency water supply and sanitation, storage of food, and moving animals to safe areas.

Another aspect of the emergency plan is mobilising the resources needed to undertake emergency work during a flood, including repairing and maintaining flood protection structures and assisting with the evacuation of people. The emergency workforce, including organisations such as SES, police, local government and volunteers, should be prepared through progressive stages of alert as warnings are received, culminating in mobilisation. The emergency workforce should be organised on a rotational basis to facilitate round-the-clock working during the flood emergency. One requirement of an emergency plan is to ensure that plant, equipment, supplies and fuel stocks for the emergency workforce are checked, serviced and replenished before the flood season.

Other relief actions depend on circumstances. They may include building temporary defences (using sandbags or other materials) and helping vulnerable people to respond to the flood, for example evacuation of the elderly and infirm.

After a flood event (post-event response), there continues to be a need for emergency planning and management to ensure its second objective of promoting recovery can be realised - the adverse effects of floods do not finish when the flood waters recede. The people and communities affected will feel the effects for many weeks or even months after the flood has occurred, and this needs to be planned for in pre-event emergency planning.

It is clear that floods have an economic impact, through damage to property and infrastructure. What has been less appreciated, until recently, is the effect that floods have on the health of the people affected. Again, this needs to be anticipated and the proper levels of assistance planned and put in place in an efficient way. In this way disruption and trauma after an event can be minimised. The issues to be considered are:

- the awareness that the post-event period is one when the effects of a flood disaster are still being felt;
- the elderly and infirm members of the public are likely to be affected most;
- the need, prior to flood events, for health and other related services to be alerted that they may be needed; and
- the recovery from these events may take months or even years.

Such activity might not appear at first sight to be part of the flood risk management process. However, it is an element of seeking to reduce the consequences of floods, and thus rightly sits alongside other response measures.

BTRC Local Disaster Management Plan 2009 - 2014
A review of the Blackall Tambo Local Disaster Management Plan revealed that flooding is identified as the hazard with the highest risk. However, a sub plan focussing on a flood event details very little information concerning aspects such as evacuation routes etc. as discussed above. The Plan does identify the SES as the lead agency in a flood event, and lists a number of protocols associated with seeking a disaster declaration, but no definitive declaration or evacuation trigger. The Plan also nominates the Council Chambers in Blackall as the Local Disaster Coordination Centre.

The location of community safe havens (evacuation centres) and how well they are fitted out to cater for numbers of people of all ages is an essential item to be addressed in the BTRC Local Disaster Management Flood Sub-Plan for Blackall. It is essential that these centres are above all not at risk of flooding which for Blackall, means in the east of town. The importance of such centres, and the community's knowledge of their existence, cannot be overstressed. It is essential that Flood Sub-Plan clearly establishes the location of evacuation centres, what facilities they have and what and where alternative sites are, in the event of either overcrowding or threat of greater depths of flooding.

The sites should be chosen on the basis of:

- the available space for short-term sleeping accommodation;
- the available space for storage of belongings;
- the capacity of the site to supply sufficient hygiene facilities; and
- the capacity of the site to service the food and beverage requirements of the evacuees.

5.3.2 Flood Warning System

The purpose of flood warning is to enable and persuade the community to take the appropriate actions to increase safety and reduce the damages associated with flooding. When properly developed and communicated, accurate and timely flood warnings are one of the most effective tools in the management of flooding, the reduction of damage and the maintenance of safety of the community.

The Bureau of Meteorology is the lead agency in the provision of flood warning services to Blackall. Where the Bureau of Meteorology believes weather patterns show a potential for flooding, Flood Watches will be issued. Where the flood data collection network shows flooding is imminent - if river levels are expected to exceed pre-defined ‘minor’ flood levels - Flood Watches are upgraded to Flood Warnings.

For the purposes of dissemination, both Flood Watches and Flood Warnings will be treated as Flood Warnings. Apart from the normal media announcements, warnings are transmitted to a range of Government Agencies, Police, Local Government and the State Emergency Service. These bodies, in turn, further disseminate the information to local organisations and groups.

The Flood Warning system commences with the issue of Flood Watches and Flood Warnings from the Bureau of Meteorology and concludes with the public receiving a detailed message about flood risk and required action.

A flood warning issued by the Bureau of Meteorology will outline the likely indicative flooding consequences. For each flood warning, a flood-warning category is issued in terms of minor, moderate or major. The definitions of the flood warning categories are as follows:

Minor flooding: Causes inconvenience. Low-lying areas next to watercourses are inundated – may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged.

Moderate flooding: In addition to the above, the evacuation of some houses may be required. Main traffic routes may be covered. The area of inundation is substantial in rural areas – requires the removal of stock.

Major flooding: In addition to the above, extensive rural areas and/or urban areas are inundated. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood-affected areas may be required.

Construction of warning messages and dissemination

A “warning message” converts the technical information of the prediction and its interpretation into news and advice for the community at risk. It is the critical step between flood prediction and interpretation on the one hand, and protective action by the community on the other.

Flood warning provides a guide for effective message design, the message should:

describe the flood;

say what is happening currently, what is expected to happen and when it will occur; and

indicate how people should act.

It is also essential that Council works in cooperation with the SES in the design of the messages. It should be noted that message templates can be prepared and included in BTRC Local Disaster Management Flood Sub-Plan for Blackall, which at present does not include any information relating to local dissemination of flood warning.

Possible protocols for information dissemination of flood warning for inclusion in the Flood Sub-Plan include:

Routine flood warnings and updates, as issued by the Bureau of Meteorology, will be disseminated by Council;

Council will develop a distribution list to enable broadcast fax forwarding of information as required throughout the Shire;

Information and reports from the public and other agencies must be recorded and passed directly to Local Disaster Management Committee Executive Officer XO for collation, confirmation and response;

Regular reports will be issued to an official information centre or location such as Council’s website.;

The information will be located at various Council centres (Blackall or Tambo etc.) on the nature and location of the event;

Council shall staff and manage the Centre, prepare public information material and attend to public enquires in person and/or over the phone;

Council staff will be tasked to contact/door knock residents that may be in flood prone areas and keep them informed of the situation either verbally or via newsletters; and

Council will arrange for the installation of dedicated tape message answering machines at the Council office during an overwhelming emergency to provide information on the emergency.

Two general categories describe message dissemination methods, general and specific. General methods are usually the “mass media”, in particular the broadcast media. Specific methods provide information and warnings to particular, pre-identified individuals, groups or organisations. These two methods should be complementary, with specific warnings reinforcing the general.

An issue facing the community of Blackall in message dissemination is the ability to make the best use of the broadcast media, particularly radio and television. Radio station ABC has a specific arrangement to broadcast flood information in the event of a significant flood. Television in Blackall is sourced from the major networks and it is likely that the SES could have difficulty in arranging a break in to the networks to broadcast the warning messages. This is because when Blackall is in flood numerous other larger more prominent towns in western Queensland are generally also in flood making it difficult for Blackall specific warnings to be disseminated by these carriers.

As indicated above, specific messages must be used to complement the general messages that are sent on the broadcast media. This is very labour intensive with the responsibility of this task not stated in the Flood Sub-Plan. It is essential that both the Council and the SES co-ordinate their resources with a data folder, held in the SES office and the Council office, that defines the duties and tasks of each organisation and details properties to be contacted. Furthermore, it is essential that these folders are kept as up-to-date as possible and that the residents with special needs are noted.

While a personalised system may be successful in relatively low floods there always remains the risk that, when a major flood occurs, the personalised system will fail and there is a need to ensure backup procedures (such as a vehicle-mounted loud hailer) and even redundancy in the process. The warning message must get through.

A challenge for any flood warning system is to calibrate upstream levels with predicted flood levels in the town area. Each flood may exhibit different flow regimes and flow characteristics. Therefore, interpreting the rate in rise of flood levels from upstream gauges and translating that into a predicted level and time of the flood arriving in the vulnerable part of the township is a challenge. However, it is not out of the question to establish this relationship.

It is recommended that any future recording of flood levels and rainfall intensities upstream of the town of Blackall be matched by recording the time of arrival of floodwaters at the town as well as flood levels. By collecting and comparing this data, any future warning system and response to that warning is likely to afford a higher protection to the community.

5.3.3 Flood Intelligence System

Flood intelligence refers to a broad collection of flood related information that is used to prepare, plan for, and respond to floods. This information is derived through historical record and technical studies. The central element of a flood intelligence system is the systematic recording, during and immediately after a flood, of information on where the water went at different stages of the event. This information can be used predicatively in later flood episodes to inform response decisions, and to provide higher-quality warnings to the community than have traditionally been possible. The building up over a period of time of a dossier of information on flood behaviour constitutes a valuable resource to guide later efforts.

One of the fundamental pieces of flood intelligence are flood intelligence records developed for the reference area around a stream gauge, both upstream and downstream. Heights at the gauge have meaning in terms of riverine flooding, independent of local flooding or flooding from tributary creeks for this area. The entries themselves should consist of the known or estimated heights at which phenomena such as the following occur:

- floodwaters encroach on specified farmlands, caravan parks, residential and business properties, community facilities, institutions (e.g. nursing homes and schools) and utilities (e.g. sewerage and water supply systems) – impacts at different locations can be indicated by map grid references;
- buildings are flooded over their floorboards;
- roads are cut, causing individual houses or communities to become isolated and traffic movements to be disrupted;
- railway lines are cut;
- airfields are inundated;
- other significant effects (including the overtopping of levees) occur or can be expected; and
- significant historic floods peaked, or particular design floods such as the 1% Annual Exceedance Probability (AEP) event or Probable Maximum Flood (PMF) would peak.

In compiling these records, care should be taken to:

- ensure that effects are correctly ascertained in a causative sense relative to gauge heights (i.e. things which happened, but which did not relate directly to specified heights being reached during a particular event, must not be recorded against those heights);
- note where an impact at a particular height at a gauge will occur only if some other effect, unrelated to that gauge, also occurs (e.g. a road being cut at a certain height, necessitating a longer journey on an alternative route between two places but with the possibility of all access being lost when this route closes as a consequence of flooding on another stream);
- ensure that effects are explicitly noted in terms of locations of impacts, roads closed to different classes of vehicles and properties affected in different ways (e.g. by inconvenience, if additional distance is added to journeys, or by complete isolation which may necessitate resupply, or by inundation); and
- keep detailed lists of affected properties by type (residential, farm, retail, industrial, caravan park, etc).

It should be noted that virtually all flood intelligence records are approximations. This is because no two flood events at a location, even if they peak at the same height, will have identical impacts. The gradients of the floods may differ, the floods may be near their peaks for different durations, and the channel and floodplain environments in which they occur are unlikely to remain static. Changes in land use in urban areas, including alterations to ground levels, raised garden beds, solid fencing and slab on ground construction can lead to localised alteration of flood levels that were not apparent at similar levels in previous flood events. Such alterations cannot be determined without detailed flood modelling combined with historical data.

The fact that height/consequence links are approximations (and in some cases may be estimates of likely occurrences) should not be of concern. Absolute precision in these matters is not necessary for effective planning to be undertaken. The alternative to imperfect information would be to have no recorded information at all on which to base operational decisions and construct warning messages. Where substantial known variability exists in the heights at which particular effects can occur, this can be noted by listing a range of heights.

Apart from recording height/effect relationships, the records may indicate specific actions that may need to be:

undertaken before specific heights are reached (e.g. barricading a road which will be dangerous to travel on or closing drainage valves to prevent backwater flooding); or

completed in advance of floodwaters reaching particular levels (e.g. moving stock before paddocks are inundated, evacuating people to safety before escape routes are cut, or removing electric motors from sewerage pumping stations to prevent submergence).

In such circumstances, indications of the amount of time required to carry out the necessary actions are particularly useful. Recording heights against consequences and actions helps develop a forward planning tool for flood managers, which allows them to look ahead to ensure responses occur at appropriate times. In turn, this will mean that actions which need to be undertaken can be carried out in advance,rather than when they become critical - which is often later than preferable. Estimating the amount of time needed to carry out these tasks will facilitate their successful completion.

5.3.4 Public Information & Flood Awareness

The success of any flood warning system and the evacuation process depends on:

Flood Awareness: How aware is the community to the threat of flooding? Has it been adequately informed and educated?

Flood Preparedness: How prepared is the community to react to the threat of flooding? Do they (or the SES) have damage minimisation strategies (such as sand bags, raising possessions) which can be implemented?

Flood Evacuation: How prepared are the authorities and the residents to evacuate households to minimise damages and the potential risk to life during a flood? How will the evacuation be done, where will the evacuees be moved to?

A community with high flood awareness will suffer less damage and disruption during and after a flood because people are aware of the potential of the situation. On river systems that regularly flood there is often a large, local, unofficial warning network that has developed over the years, and residents know how to respond to warnings by raising goods, moving cars, lifting carpets, etc. Photographs (of less importance with digital photography) and other non-replaceable items are generally put in safe places.

Often residents have developed storage facilities, buildings, etc., which are flood compatible. The level of trauma or anxiety may be reduced as people have “survived” previous floods and know how to handle both the immediate emergency and the post flood rehabilitation phase in a calm and efficient manner. To some extent, the community has already addressed many of the above issues for Blackall, because of the 1990 flood experience.

The level of flood awareness within a community is difficult to evaluate. It will vary over time and depends on a number of factors.

Frequency and impact of previous floods: A major flood causing a high degree of flood damage in relatively recent times will increase flood awareness. If no floods have occurred, or there have been a number of small floods, which cause little damage or inconvenience, then the level of flood awareness may be low.

History of residence: Families who have owned properties for a long time will have established a considerable depth of knowledge regarding flooding, and a high level of flood awareness. A community that consists predominantly of short lease rental homes will have a low level of flood awareness – it would appear that the majority of the residents won’t have lived in the area for very long and are, therefore, unfamiliar with flooding. However, it is very likely that new residents will be aware from advice at the time of their property purchase or from neighbours after they move in. It is very unlikely that a new resident buying a house in flood prone areas of Blackall will not be aware of the potential of flooding.

Whether an effective public awareness program has been implemented: It is understood that no large-scale awareness program has been implemented in the past.

For risk management to be effective it must become the responsibility of the whole community. It is difficult to assess the benefits of an awareness program, but it is considered that the benefits far outweigh the costs. The perceived value of the information and level of awareness diminishes as the time since the last flood increases.

A major hurdle is often convincing residents that major floods will occur in the future. Many residents hold the false view that once they have experienced a large flood then another will not occur for a long time thereafter. This viewpoint is incorrect, as a 100 year ARI (or sometimes termed a 1% AEP event) has the same chance of occurring (1%) in any subsequent year, regardless of the magnitude of an event that may have recently occurred.

A similar analogy is after “tossing” a coin, say 5 times and coming up with “heads” each time, the chance of “heads” on the next throw is still 50:50.

Based on feedback it would appear that the majority of residents in Blackall have a medium level of flood awareness and preparedness. However, this may not be the case for the “holiday” visitors.

As time passes since the last significant flood, the direct experience of the community with historical floods will diminish. It is important that a high level of awareness is maintained through implementation of a suitable Flood Awareness Program that would include Floodsafe brochures as well as advice provided on the Council and SES’s websites. These need to be updated on a regular basis.

It is recognised that there are a number of flood-related messages that need to be conveyed to the public as part of a flood awareness program. These messages, along with the type of information that should be used to convey the message is provided in Table 13 below.

Table 13: Flood awareness messages

MESSAGE	NECESSARY INFORMATION
General flood information	Floods can cause damage to property and endanger human life; different types and sizes of floods
General flood preparedness advice	What to do to prepare for a flood
You live in a flood prone area	Floods can occur in your area (and have in the past)
Location specific flood information	Type of flooding in the area; nearest stream gauge (and relation to floor / ground level); likely speed of onset; historical flood level; residual risk (e.g. behind levees)
Location specific evacuation information	Evacuation routes and centres; where to find evacuation information (radio stations, road closed websites)
Details on flood management schemes / initiatives	What has been completed and planned; how initiatives manage flooding; timeframes for implementation etc.
You own a local business	Brochure with “is your business flood aware and ready”. Businesses may need to put in place a flood management procedure or and “high and dry” procedure.

The conveyance of these messages can be through a range of formats; it will be necessary to select the best format for the message and the targeted audience. Possible formats include:

- Informative flyer with utility bill / rates notice (can be general or targeted to flooding in specific areas);
- Briefings at social and civic clubs, e.g. Rotary, Lions;
- Expert panels (flooding, emergency and planning experts);

- Newspaper feature story on general flooding issues or historical (flood commemorations);
- Information booth at community festivals, shows etc.;
- Information repository at libraries, Council office etc.;
- Newspaper insert (fact-sheet style);
- Flood information website;
- Signposting of evacuation routes;
- Noticeboards in public areas to signpost floodways, structures etc.
- School projects on floods and floodplain management;
- Historical flood markers;
- Flood certificates; and
- Email newsletters.

The specific flood awareness measures that are implemented will need to be developed by Council, taking into account the views of the local community, funding considerations and other awareness programs. The details of the exact measures would need to be developed in consultation with affected communities.

There exists a huge variety of flood related information and awareness programs and resources available to communities and business that Council, in conjunction with the SES, could model a local Floodsafe type program.

It is recommended that Council, in conjunction with the SES, develop a program to increase community awareness of existing flood risks, flood emergency response and flood warning arrangements. The program should at least outline contact phone numbers, context of local flooding issues, flood warning arrangements, and tips for reducing damage and enhancing safety.

In addition to information about the effects and risks of floods, it is important that the community has an understanding of historical and design flood behaviour. This technical information may include flood depths, hazards and extents. Provision of this information will help the community understand the magnitude of the flood problem and the level of flood risk in their location.

5.4 Property Modification Measures

Property modification measures seek to reduce flood risk through careful planning of future developments. Property modification measures can also be applied to existing developments to either reduce the flood risk by raising the house, or by removing the property from the flood prone location altogether.

5.4.1 Voluntary Building Protection Retrofits

Protection retrofitting refers to the design and construction of buildings with appropriate water-resistant materials such that flood damage to the structure of the building itself (i.e. structural damage) is minimised when the building is flooded. At best, flood proofing is an adjunct to other management measures.

The decision to adopt flood proofing as a formal mitigation measure is best made from within the framework of a floodplain management plan. Whilst flood proofing can minimise structural damage to flood affected buildings, the occupiers of flood-affected buildings still suffer the social disruption of flooding.

To prevent or minimise structural damage from flooding, buildings should be designed to withstand water immersion and debris and flotation forces. Particular methods of construction and certain types of materials are better able to withstand immersion than others. For example, plasterboard and chipboard, materials commonly used for internal wall linings and built-in cupboard fittings, respectively, are generally irreparably damaged on immersion - even to a minimal depth - and have to be replaced. In contrast, double brick construction can withstand immersion and may only need a 'hose and scrub down' when the flood subsides.

The most effective flood proofing measure is to raise habitable floors to some 'defined floor level'. However, in commercial buildings the choice of floor level is also affected by economics and commercial risk-taking considerations. This can result in a commercial enterprise preferring to build the cost of flood losses into its operating costs in exchange for savings in capital costs associated with not having to raise floors to some higher level.

Councils have a duty of care in approving such 'non-conforming' developments and in deciding on appropriate conditions. They may require the proponent to submit detailed advice of measures proposed to avoid or cater for flood losses. Such measures to mitigate impacts are required to be proved for any new development in flood prone areas. These requirements are built into the provisions of the draft planning scheme.

Irrespective of the proponent's desires, the overriding consideration should be that the proposed development will not adversely affect flood behaviour or increase the risk to life, limb or property, whether public or private.

The proper course is to determine levels of acceptable risk for specific areas of the floodplain and for specific land uses from within the overall framework of a flood risk management process.

Further, decisions for non-conforming developments must not be made on an ad hoc or isolated basis. Rather, such decisions must be taken based on the cumulative development of the floodplain.

It is recommended that Council include in a Floodsafe type program, information (guidelines) for both residences and business along with flood awareness maps.

5.5 Summary

The recommended risk management measures for further consideration are summarised in Table 14 below. The impacts of these measures on Blackall will be addressed in the subsequent Preliminary Flood Risk Management Plan.

Table 14: Assessment of potential flood risk management measures

RISK MANAGEMENT MEASURE	COMMENT	RECOMMENDED FOR FLOODPLAIN MANAGEMENT PLAN
Flood Modification Measures		
Flood Mitigation Dams	Not considered	No
Levees, Flood Gates & Pumps	May be viable need to carefully consider height and extent, i.e. all areas subject to inundation or just parts e.g. CBD. Both a permanent and temporary levee (mobile barrier) will be examined.	Yes
Detention Basins / Retarding Basins	Not a suitable measure for Barcoo River	No
Channel Modifications	Changing channel geometry not viable, addressing floodplain and riverine vegetation will have no significant impact on flooding characteristics.	No
Bypass Floodways	Perhaps but ultimately considered not economically feasible	No
Response Modification Measures		
Emergency Planning & Management	Urgent, LDMP requires expansion with a	Yes

	focus on activity triggers e.g. evacuation, safe havens and general protocols and procedures re flood emergency	
Flood Warning	Essential part of overall flood management plan. Recently expanded network will help immensely. Opportune time to review information systems etc. and how this links with flood intelligence	Yes
Flood Intelligence	Identified as a shortcoming, haphazard at best at the moment; requires systematic management. Can be a very simple but quite powerful tool.	Yes
Public Information & Flood Awareness	Identified as a shortcoming, many possibilities that could be progressed. Emphasis on information messages and awareness	Yes
Property Modification Measures		
Voluntary Building Purchase Scheme	Not considered feasible	No
Voluntary Building Raising	Not considered feasible	No
Voluntary Protection Retrofitting	Residents and business owners would need guidance and support, may not gather traction if not subsidised	Yes

6 Planning Considerations & Future Development

Although development in Blackall does not experience the pressures of larger towns and cities, this Flood Risk Management Study can lay a strong foundation for activity be used by planners and policy makers to help respond to flood hazards, and to identify issues to consider in developing appropriate land use responses for the township. The draft planning scheme considers both current levels of development and potential development scenarios should mineral exploration in the area increase the development level of the town.

Very simply, better flood risk management results in communities that are more resilient. Land use planning, as a key component of the flood risk management process, can greatly assist in improving community resilience.

To date in Queensland, assessment of flood risk in the land use planning process has generally been addressed through the development assessment process. Ideally, though, land use provisions, including strategic frameworks and zoning plans tailored to the unique conditions of the floodplain would be included in the planning scheme.

In particular, there is a key role for the strategic framework component of new Queensland Planning Provision (QPP) compliant planning schemes to clearly articulate the community's vision and response to flood risk, and to set land use policy and planning scheme provisions to meet that vision.

Clear planning scheme provisions are likely to reduce the reliance on applicants to undertake site-specific flooding investigations, and reduce the obligation of councils to make development assessment decisions that may not be uniformly consistent.

An analysis of the draft BTRC planning scheme shows that strategic intent, zoning and assessment provisions have provided a balance between community expectations, financial considerations (regarding potential for compensation from back zoning) and the precautionary principle to be risk averse in decision making. The draft planning scheme defines the flood event level and secures a policy position to reduce development yields in flood prone areas by both land use and fiscal constraints.

Any new development in flood prone areas cannot increase development yields, and requires increased costs in development contributions, construction and assessment costs.

Table 17: The range of potential land use responses to flood risk and their incorporation into the BTRC draft planning scheme

Land Use Response	Land Use Strategy	Draft BTRC Planning Scheme Comments
Maintain the status quo		
Make no changes to existing land uses as risk is minimal	- None required	
Adapt existing urban areas		
Support built form change over time	- Improve built form outcomes through urban design and building code controls	- Floor height limits incorporated in the draft scheme
	- Promote traditional Queensland building designs & construction methods	- The floor height limit means that a slab on ground house cannot be constructed in the flood prone areas
	- Set habitable floor levels	- Floor height limits incorporated in the draft planning scheme
	- Build with resilient materials	- The draft planning scheme does not do this but the floor height limit gives a high level of immunity
	- Maintain/rehabilitate natural waterways and flow paths	- While floor height limits incorporated in the draft planning scheme plus other controls allow this, no specific provisions have been incorporated due to the reduced impact of flood water velocity
	- Avoid filling to minimise cumulative impacts on floodplain	- Operational works provisions in flood prone areas have been strengthened in the draft planning scheme over those available in the current scheme
Limit certain land uses that are not appropriate for the hazard	- Adjust current zonings to reflect appropriate land uses	- While the current zoning extents have not been adjusted the provisions within the scheme have been to strengthen flood resilience
	- Create flood-constrained precincts within zones, which may limit certain land use types or density increases.	- Such provisions have been incorporated into the draft planning scheme
Retreat from specific existing urban areas		
Remove existing vulnerable land uses from areas of highest risk	- Actively transition existing at-risk land uses	- This is a policy matter for the council i.e. outside the draft planning scheme
	- Back-zone areas of highest concern	- Not incorporated in the draft planning scheme to avoid compensation claims

Land Use Response	Land Use Strategy	Draft BTRC Planning Scheme Comments
	- Investigate planned retreat programmes such as voluntary purchase, land swaps, compulsory acquisition to complement scheme response	- Not incorporated into the draft planning scheme as a direct zoning. Strategic intent could be altered but would be best to wait after draft goes on display
Expand into new areas suitable for urban development		
Allocate future urban areas in areas of lowest or no risk	- Avoid zoning areas of medium or highest concern for future urban purposes.	- The draft planning scheme achieves this.
	- Site-based investigations during application stage may identify additional areas of concern. Avoid inappropriate land uses in these areas.	- Floor height limits incorporated in the draft planning scheme as well as other provisions that are designed to seek assessment of risk.
Maintain agricultural and rural landscape values		
Support flood-appropriate land uses in non-urban areas	- Tailor rural land uses appropriate to the areas of concern.	- The draft planning scheme adequately deals with the rural land uses within its jurisdiction.
Treat risks to linkages and isolated places		
Ensure transport and infrastructure routes are resilient to the hazard, and address isolation risks created through interruptions to such linkages	- Avoid creating additional risks by not placing key transport/infrastructure linkages in floodable areas, or by ensuring their resilience to those events.	- The draft planning scheme does not promote any greenfield development in areas of high flood risk and would avoid placing any new linkages in areas subject to flooding

6.1 Using the planning scheme to build flood resilience

A planning scheme needs to have a clear line of sight in how it deals with natural hazard risks. This line of sight provides a clear linkage throughout the document to ensure that all levels of the planning scheme appropriately and consistently reflect the desired approach to dealing with flood risk in the planning scheme area.

The line of sight is based on two key elements – understanding the hazard/risk, and the community's intentions for responding to that risk.

The balance of the scheme can then be calibrated to respond to these elements.

The following three components of new QPP-compliant planning schemes are considered to be the most effective tools to mitigate natural hazard risks (including floods) through a statutory planning mechanism for a local government in Queensland.

1. **Strategic framework -** sets the vision and land use direction for the planning scheme and forms the basis for ensuring that appropriate development occurs within the planning scheme area. The draft BTRC planning scheme indicates the Council's future direction for the growth of Blackall is in infill development with increased yields in those areas with very little risk of flooding.

2. **Zones (including precincts)** – ensure that development within the scheme area responds to the desired outcomes contained in the strategic framework by setting clear land use intent and calibrating levels of assessment for development that reflect the strategic intent. The draft BTRC planning scheme seeks to introduce mechanisms to make if financially difficult to develop in flood prone areas while ensuring areas of less risk of flooding have increase development opportunities and lower development costs.

3. **Overlays –** provide further assessment criteria for specific constraints or opportunities (such as flood hazard) within the scheme area, such as built form controls. The draft BTRC planning scheme introduces a trigger map for a defined flood event and builds extra assessment criteria into assessment process, within the zone codes, to manage any potential development scenarios in land that is subject to a high risk of flooding.

BTRC may also use other scheme mechanisms (such as planning scheme policies or planning partnerships) to also address flood risk as desired. A planning scheme policy could give guidance to prospective applicants in flood affected areas, as to the matters to consider in drafting a response to the planning requirements. However, such a policy may assist in encouraging development rather than discouraging it.

A key role for the strategic framework is to define the desired settlement pattern for Blackall. The settlement pattern proposed by Council should be developed, taking into consideration expected population growth, economic development strategies, existing urban areas and desired built form outcomes. It should also be informed by responses to, among other things, flood hazard.

It is also the role of the strategic framework to articulate the extent to which the community accepts or tolerates natural hazard risk, what resilience target is appropriate to strive for through the life of the planning scheme, and how the community wishes to address the risk of natural hazard, having regard to other factors such as population growth and economic development. This policy position then, needs to filter down into the detailed planning scheme provisions, such as zones and overlays.

There is a key role for a community vision in defining the conceptual way forward for development within the planning scheme area, as the more detailed policy positions in the strategic framework will be informed by this vision. The vision, as it relates to natural hazard risk, will be built upon the community's acceptance of risk and the resilience target identified. The vision can then assist planners to calibrate the land use plan (e.g. zoning) and detailed assessment mechanisms such as codes within the scheme to address exactly what the community intends for the area.

6.2 Hazard maps vs risk maps

A key output of the Flood Risk Management Strategy are the maps showing the level of identified flood risk at a property level. This mapping will be used to inform strategic planning and to calibrate zonings for properties affected by flood, where this has been identified as an appropriate risk treatment option.

However, it is important that the flood hazard map be included in any planning scheme, not the flood risk map developed. As the scheme cannot accurately predict every type of development that may be proposed within BTRC area, the risks presented by future development may change.

For example, Council may identify a rural, undeveloped area at 'acceptable' risk because it is not an urban settlement and is not envisaged as such under the life of the scheme. This risk level is appropriate for this current circumstance, though there may be instances where development not envisaged by the planning scheme occurs.

For example, resource/mining activity that commences after the scheme is adopted triggers the need for additional urban development (a residential subdivision, for example) in that area. As it was not identified as a future urban area in the scheme, the stated 'acceptable' level of risk for the area is not appropriate to assess the development. Therefore, a risk map is not appropriate for inclusion in a planning scheme, but should be used to inform the strategic land use planning process and the allocation of zonings based on the identified levels of risk.

A hazard map is the correct mechanism to assess the appropriateness of the land use though the development assessment process. This is because the hazard map will depict the actual nature of the flood – i.e. how 'hazardous' it is.

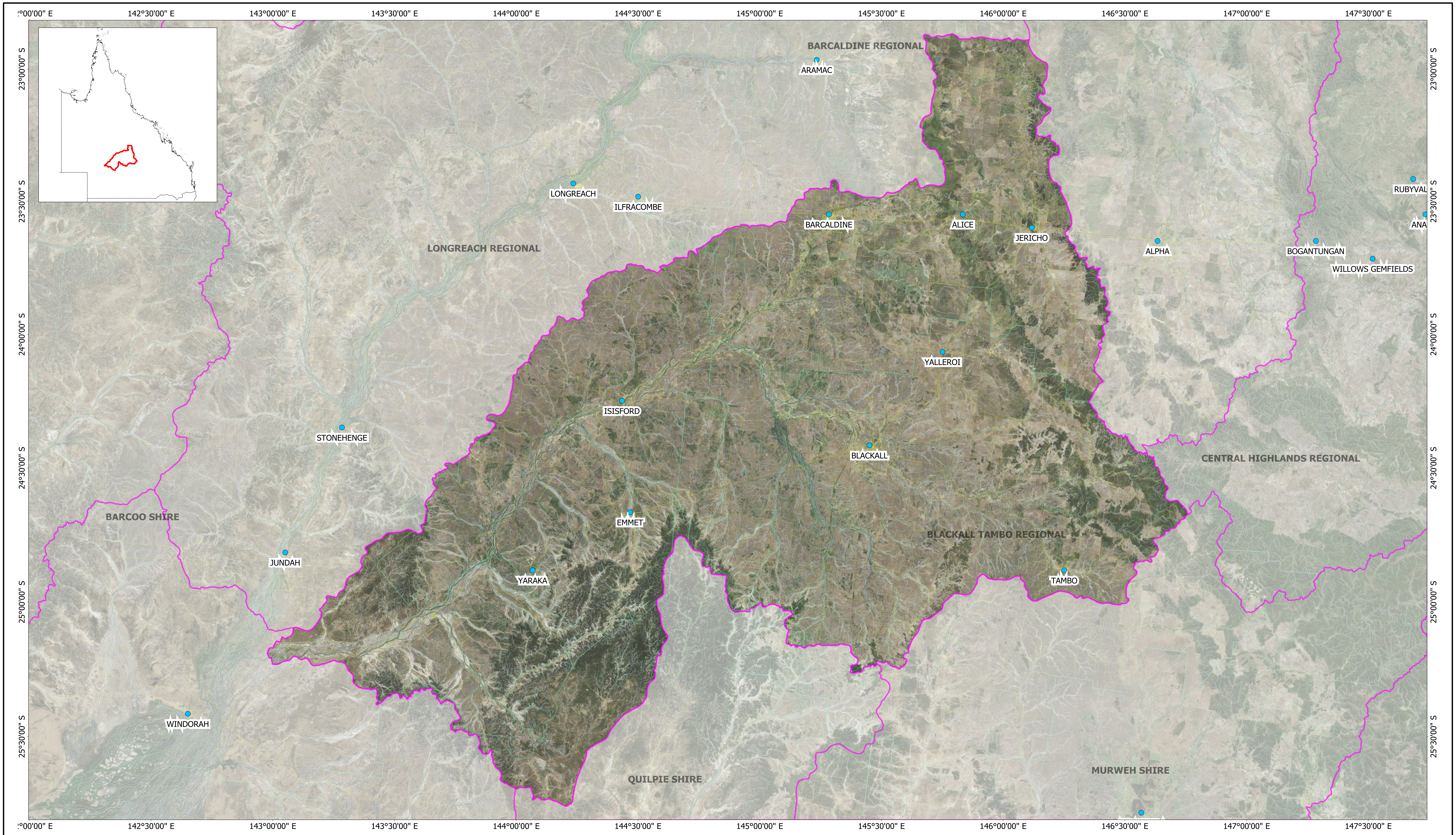
The draft BTRC planning scheme introduces a trigger map as an overlay indicating a defined flood event level, and associated contours, so further assessment can occur if development applications are made on land triggered by this map. Further to this, the flood affected land is outside the priority infrastructure area further decreasing the land's development potential.

House flooded by the Barcoo River, 1906. Rough, timber house affected by the Barcoo River. Two men stand under the awning as the water encroaches upon the property. 4 February 1906 John Oxley Library, State Library of Queensland

*Flood in the Barcoo River, Blackall district, February 1941.
1 February 1941 John Oxley Library, State Library of Queensland*

Appendix A

MAP 8: BARCOO RIVER SUB BASIN



Map 8: Barcoo River Sub Basin

Job: J13_16_Blackall Flood Risk Management Study
Client: DC Solutions & Blackall Tambo Regional Council

- Population Centres
- Sub Basins
- Local Government Boundaries
- Digitak Cadastre
- Drainage_250K

N

Datum: World Geodetic 1984 (WGS84) Auto
Coordinate System: Mercator
Scale: 1:1700000 printed on A3

0 100 km

Date Produced: 24/02/2014 10:47:59 AM By: Administrator WorkStation: CENTRALSERVER FilePath: Y:\YARRAMINE\JOBS\2013\J13_16 - Blackall Flood Mitigation Studies - DC Solutions\Mapping Files\Mapping Files\Blackall.map Printer: Samsung CLX-6200 Series Contact Details: Yarramine Environmental PO Box 2588 TOOWOOMBA QLD 4350 (07) 46382442 www.yarramine.com.au

Appendix B

MAP 10: TOWNSHIP OF BLACKALL

Map 10: Township of Blackall

Job: J13_16_Blackall Flood Risk Management Study
Client: DC Solutions & Blackall Tambo Regional Council

Points of Interest

Virtual Earth Hybrid Image

N

Datum: World Geodetic 1984 (WGS84) Auto
Coordinate System: Mercator
Scale: 1:15000 printed on A3

0 500 m

Appendix C

MAPS 1-7: QUEENSLAND RECONSTRUCTION AUTHORITY FLOOD MAPPING

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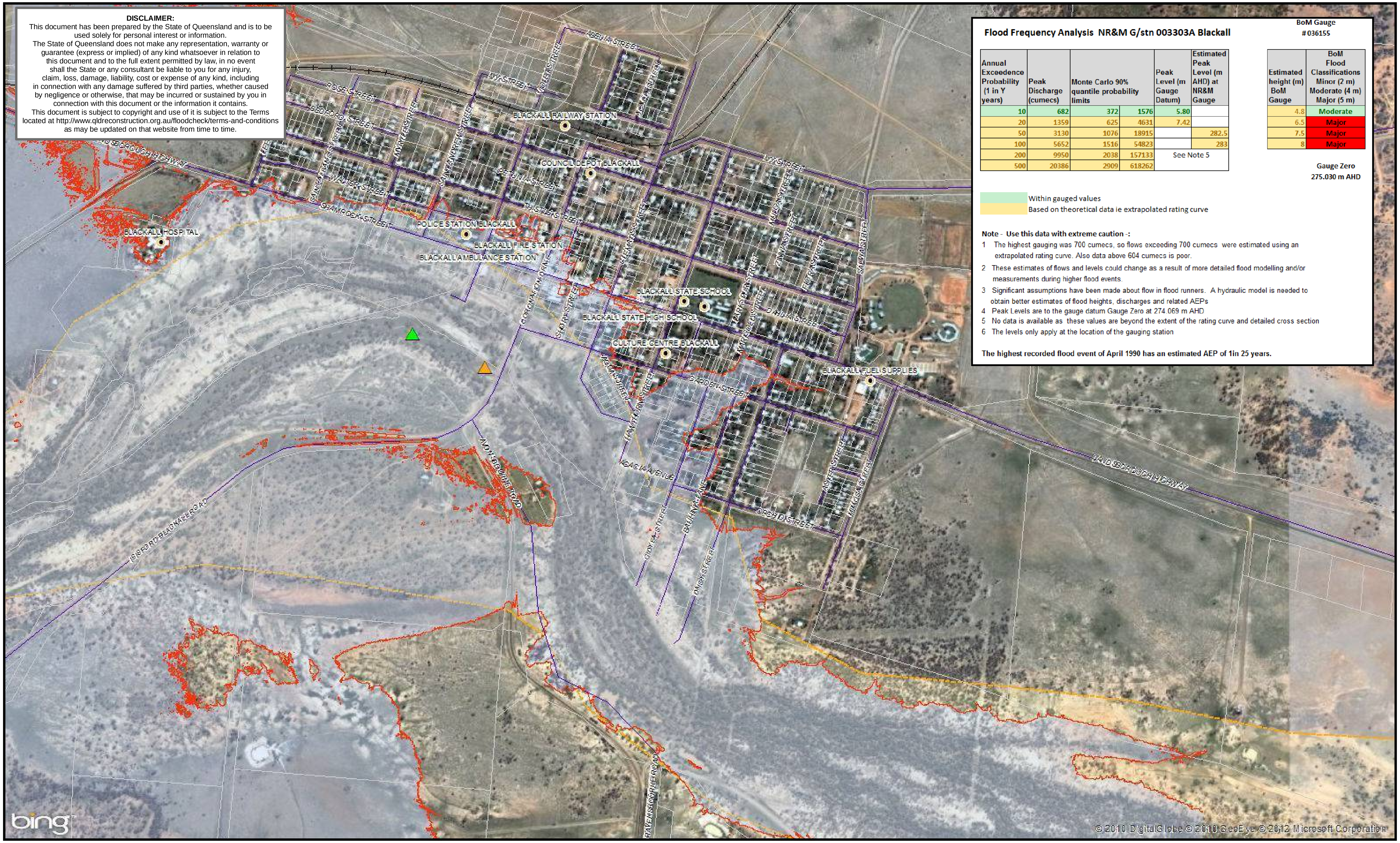

Flood Frequency Analysis NR&M G/stn 003303A Blackall

Annual Exceedence Probability (1 in Y years)	Peak Discharge (cumecs)	Monte Carlo 90% quantile probability limits		Peak Level (m Gauge Datum)	Estimated Peak Level (m AHD) at NR&M Gauge
10	682	372	1576	5.80	
20	1359	625	4631	7.42	
50	3130	1076	18915		282.5
100	5652	1516	54823		283
200	9950	2038	157133	See Note 5	
500	20386	2909	618262		

BoM Gauge
036155

Estimated height (m) BoM Gauge	BoM Flood Classifications Minor (2 m) Moderate (4 m) Major (5 m)
4.8	Moderate
6.5	Major
7.5	Major
8	Major

Gauge Zero
275.030 m AHD

Within gauged values
Based on theoretical data ie extrapolated rating curve

Note - Use this data with extreme caution -:

1 The highest gauging was 700 cumecs, so flows exceeding 700 cumecs were estimated using an extrapolated rating curve. Also data above 604 cumecs is poor.
2 These estimates of flows and levels could change as a result of more detailed flood modelling and/or measurements during higher flood events.
3 Significant assumptions have been made about flow in flood runners. A hydraulic model is needed to obtain better estimates of flood heights, discharges and related AEPs
4 Peak Levels are to the gauge datum Gauge Zero at 274.069 m AHD
5 No data is available as these values are beyond the extent of the rating curve and detailed cross section
6 The levels only apply at the location of the gauging station

The highest recorded flood event of April 1990 has an estimated AEP of 1in 25 years.

Queensland Reconstruction Authority
1800 110 841
www.qldreconstruction.org.au
Queensland Reconstruction Authority

Points of interest
Roads
Rail
Interpolated flood line
BOM gauging station
NRM gauging station
Cadastre
Interim Floodplain Assessment Overlay

Local Authority: Blackall Tambo Regional Council
Locality: Blackall
Datum: Horizontal- Geocentric Datum of Australia 1994 (GDA94)
Projection: Horizontal- Geocentric Datum of Australia 1994 (GDA94)

0 100 200 300 400
Metres
Scale at A3 - 1:14,000

Flood Investigation Level 2 Map 1 Blackall
Draft Indicative Extent of Flood Event (April 1990)
[7.3m at BOM Gauge # 036155]

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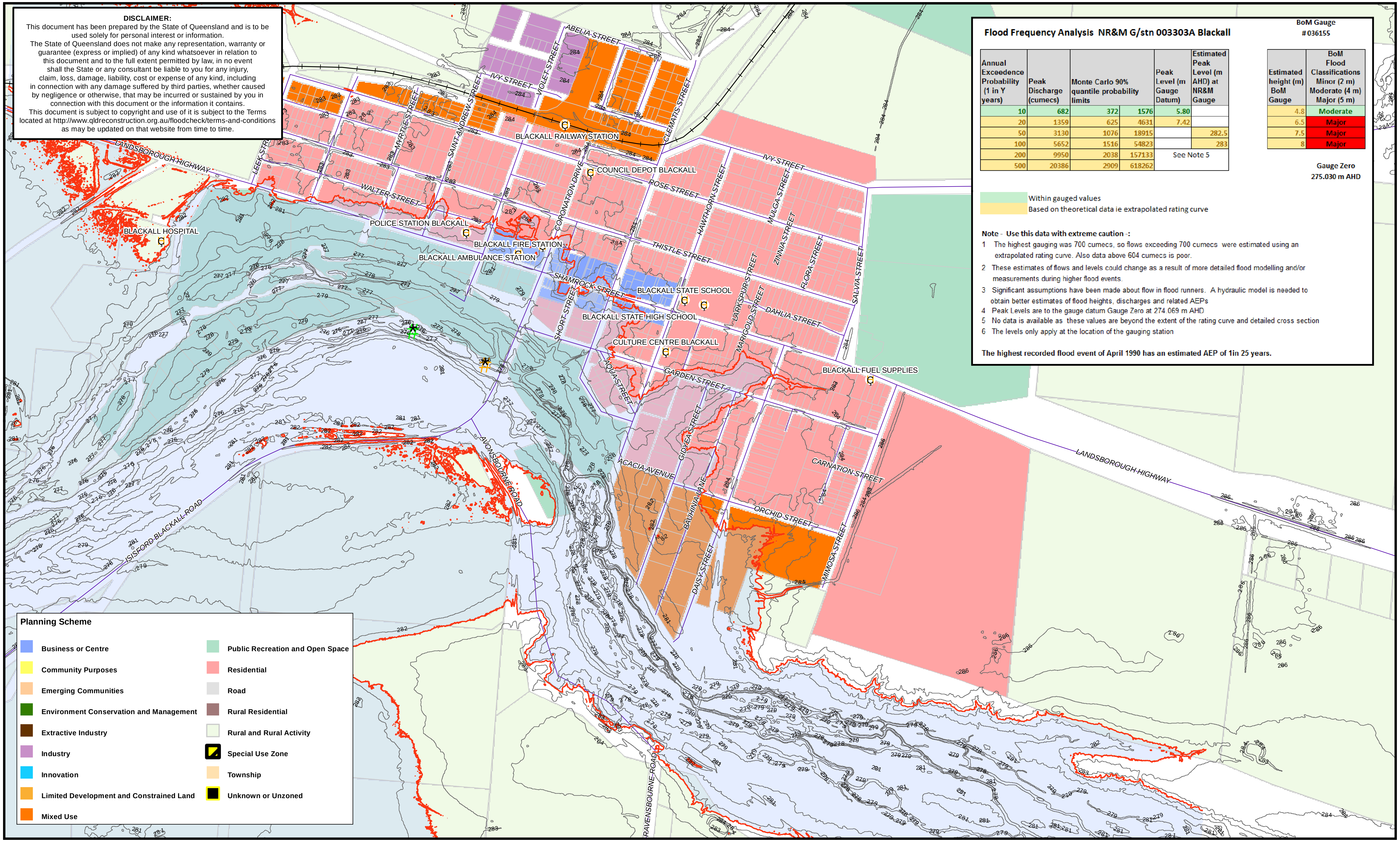

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Flood Frequency Analysis NR&M G/stn 003303A Blackall

Annual Exceedence Probability (1 in Y years)	Peak Discharge (cumecs)	Monte Carlo 90% quantile probability limits		Peak Level (m Gauge Datum)	Estimated Peak Level (m AHD) at NR&M Gauge
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100	5652	1516	54823		283
200	9950	2038	157133	See Note 5	
500	20386	2909	618262		

BoM Gauge
036155

Estimated height (m) BoM Gauge	BoM Flood Classifications Minor (2 m) Moderate (4 m) Major (5 m)
4.8	Moderate
6.5	Major
7.5	Major
8	Major

Gauge Zero
275.030 m AHD

Within gauged values
Based on theoretical data ie extrapolated rating curve

Note - Use this data with extreme caution -:

1 The highest gauging was 700 cumecs, so flows exceeding 700 cumecs were estimated using an extrapolated rating curve. Also data above 604 cumecs is poor.
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4 Peak Levels are to the gauge datum Gauge Zero at 274.069 m AHD
5 No data is available as these values are beyond the extent of the rating curve and detailed cross section
6 The levels only apply at the location of the gauging station

The highest recorded flood event of April 1990 has an estimated AEP of 1in 25 years.

Planning Scheme

- Business or Centre
- Community Purposes
- Emerging Communities
- Environment Conservation and Management
- Extractive Industry
- Industry
- Innovation
- Limited Development and Constrained Land
- Mixed Use
- Public Recreation and Open Space
- Residential
- Road
- Rural Residential
- Rural and Rural Activity
- Special Use Zone
- Township
- Unknown or Unzoned

Queensland Reconstruction Authority
1800 110 841
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- Points of Interest
- Roads
- Rail
- BOM gauging station
- NRM gauging station
- Interpolated flood line
- Contour (1m interval)
- Cadastre

Local Authority: Blackall Tambo Regional Council
Locality: Blackall
Datum: Horizontal- Geocentric Datum of Australia 1994 (GDA94)
Projection: Horizontal- Geocentric Datum of Australia 1994 (GDA94)

0 100 200 300 400
Metres
Scale at A3 - 1:14,000

Flood Investigation Level 2 Map 2 Blackall
Planning Scheme and Draft Indicative Extent of Flood Event (April 1990)
[7.3m at BOM Gauge # 036155]

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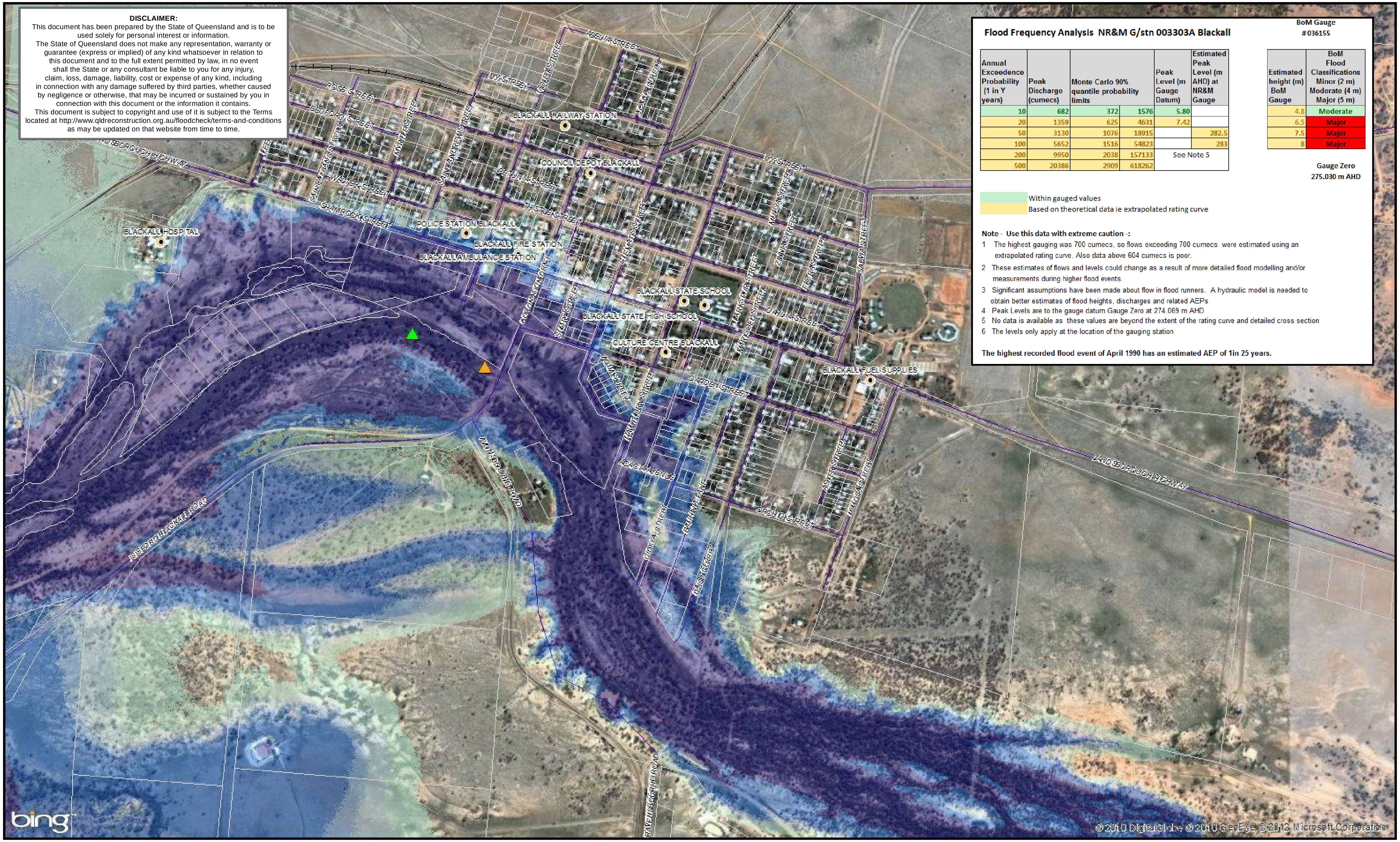

Flood Frequency Analysis NR&M G/stn 003303A Blackall

Annual Exceedence Probability (1 in Y years)	Peak Discharge (cumecs)	Monte Carlo 90% quantile probability limits		Peak Level (m Gauge Datum)	Estimated Peak Level (m AHD) at NR&M Gauge
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50	3130	1076	18915		282.5
100	5652	1516	54823		283
200	9950	2038	157133	See Note 5	
500	20386	2909	618262		

BoM Gauge
#036155

Estimated height (m) BoM Gauge	BoM Flood Classifications Minor (2 m) Moderate (4 m) Major (5 m)
4.8	Moderate
6.5	Major
7.5	Major
8	Major

Gauge Zero
275.030 m AHD

Within gauged values
Based on theoretical data ie extrapolated rating curve

Note - Use this data with extreme caution -:

1 The highest gauging was 700 cumecs, so flows exceeding 700 cumecs were estimated using an extrapolated rating curve. Also data above 604 cumecs is poor.
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The highest recorded flood event of April 1990 has an estimated AEP of 1in 25 years.

Queensland Reconstruction Authority
1800 110 841
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Queensland Reconstruction Authority

Points of interest
Roads
Rail
BOM gauging station
NRM gauging station
Cadastre

Depth (m)
0 - 0.5
0.5 - 0.8
0.8 - 1
1-2
>2

Local Authority: Blackall Tambo Regional Council
Locality: Blackall
Datum: Horizontal- Geocentric Datum of Australia 1994 (GDA94)
Projection: Horizontal- Geocentric Datum of Australia 1994 (GDA94)

0 100 200 300 400
Metres
Scale at A3 - 1:14,000

Flood Investigation Level 2
Map 3 Blackall
Draft Indicative Extent and Depth of Flood Event (April 1990)
[7.3m at BOM Gauge # 036155]

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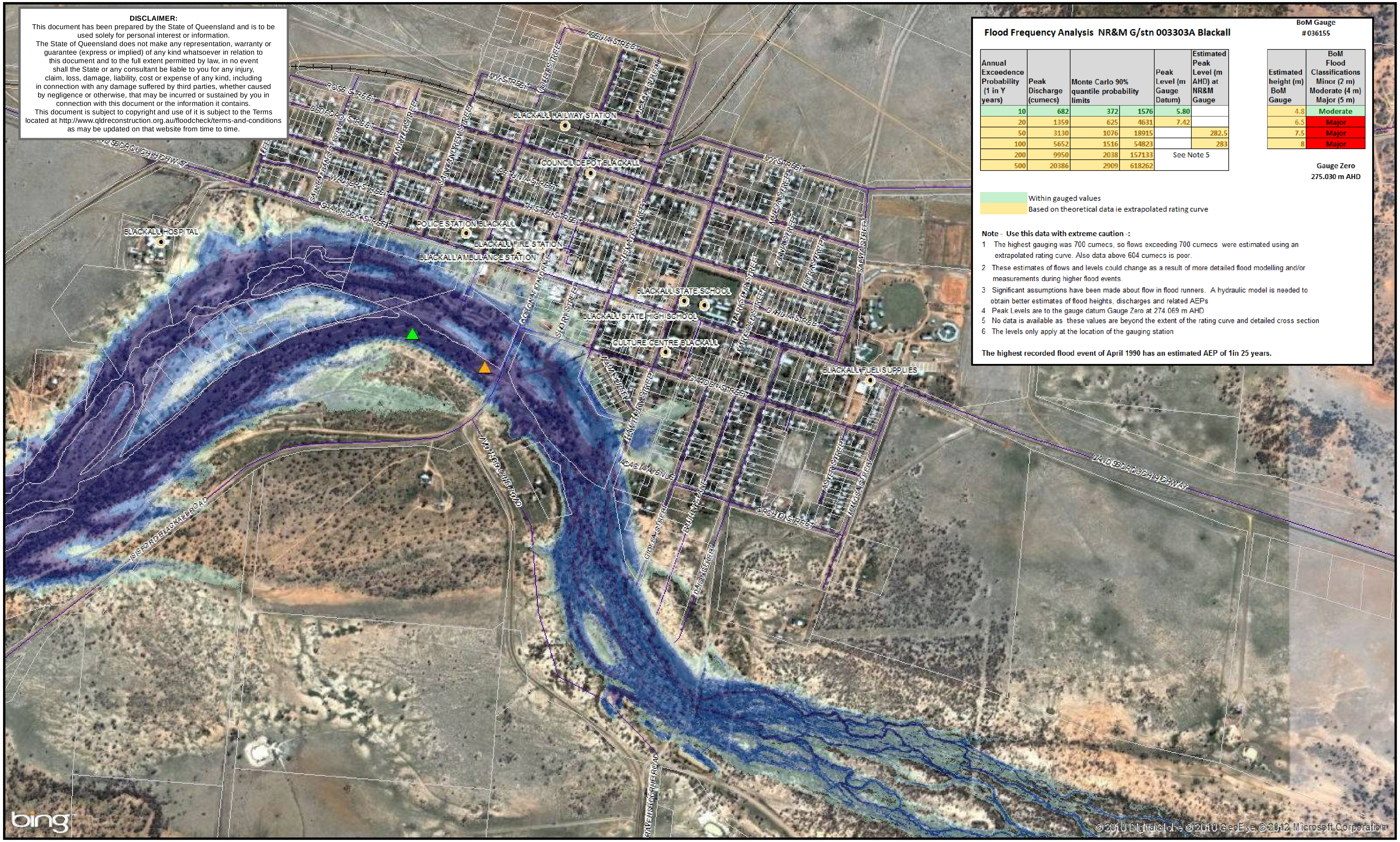

Flood Frequency Analysis NR&M G/stn 003303A Blackall

Annual Exceedence Probability (1 in Y years)	Peak Discharge (cumecs)	Monte Carlo 90% quantile probability limits		Peak Level (m Gauge Datum)	Estimated Peak Level (m AHD) at NR&M Gauge
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20	1359	625	4631	7.42	
50	3130	1076	18915		282.5
100	5652	1516	54823		283
200	9950	2038	157133	See Note 5	
500	20386	2909	618262		

BoM Gauge #036155

Estimated height (m) BoM Gauge	BoM Flood Classifications Minor (2 m) Moderate (4 m) Major (5 m)
4.8	Moderate
6.5	Major
7.5	Major
8	Major

Gauge Zero 275.030 m AHD

Within gauged values
Based on theoretical data ie extrapolated rating curve

Note - Use this data with extreme caution -:
1 The highest gauging was 700 cumecs, so flows exceeding 700 cumecs were estimated using an extrapolated rating curve. Also data above 604 cumecs is poor.
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3 Significant assumptions have been made about flow in flood runners. A hydraulic model is needed to obtain better estimates of flood heights, discharges and related AEPs
4 Peak Levels are to the gauge datum Gauge Zero at 274.069 m AHD
5 No data is available as these values are beyond the extent of the rating curve and detailed cross section
6 The levels only apply at the location of the gauging station

The highest recorded flood event of April 1990 has an estimated AEP of 1in 25 years.

Queensland Reconstruction Authority
1800 110 841
www.qldreconstruction.org.au

Points of interest
Roads
Rail
BOM gauging station
NRM gauging station
Cadastre

Depth (m)
0 - 0.5
0.5 - 0.8
0.8 - 1
1-2
>2

Local Authority: Blackall Tambo Regional Council
Locality: Blackall
Datum: Horizontal- Geocentric Datum of Australia 1994 (GDA94)
Projection: Horizontal- Geocentric Datum of Australia 1994 (GDA94)

0 100 200 300 400
Metres
Scale at A3 - 1:14,000

Flood Investigation Level 2
Map 4 Blackall
Draft Indicative Extent and Depth of Estimated Flood AEP 1 in 10 yrs
[4.9m at BOM Gauge # 036155]

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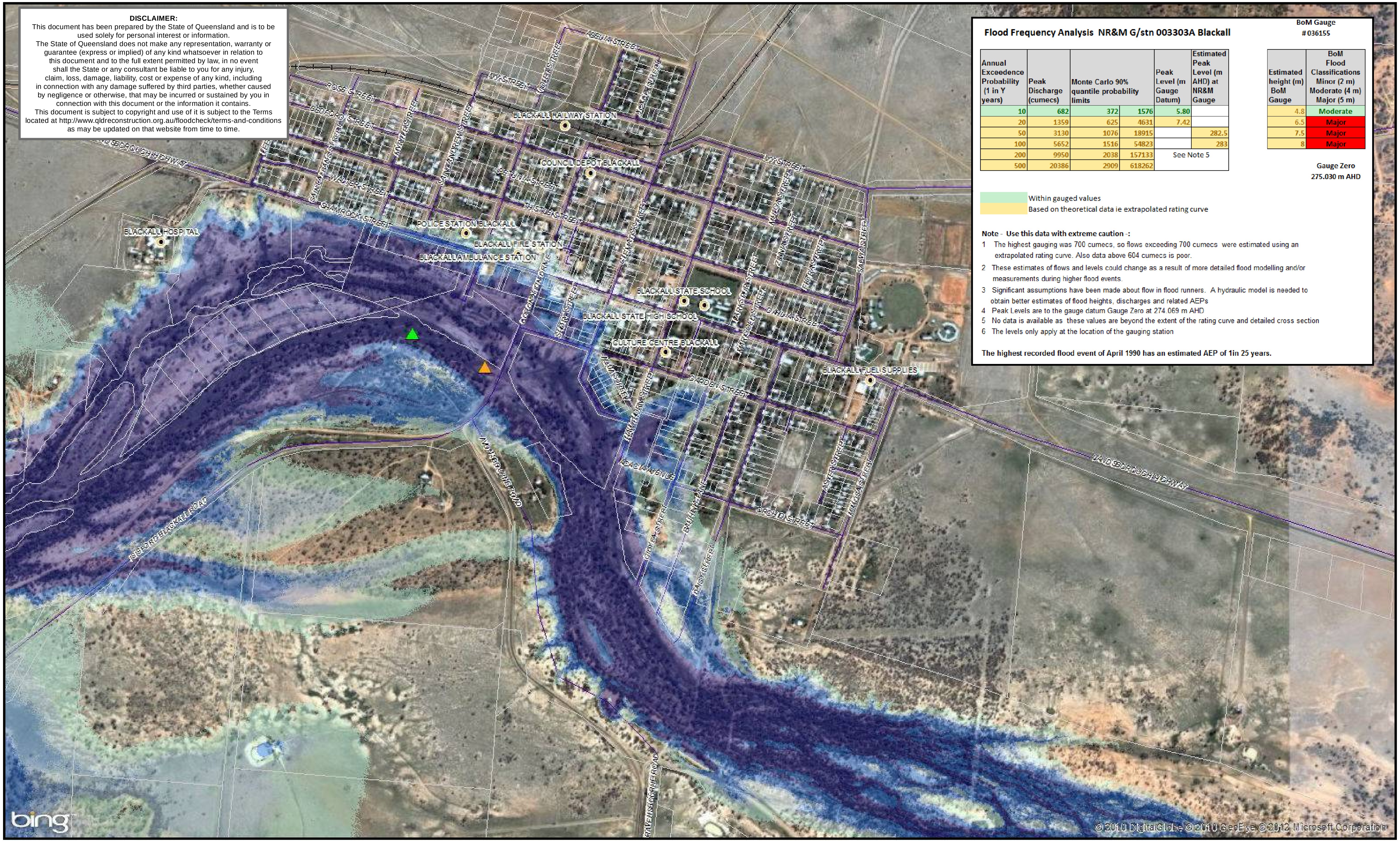

Flood Frequency Analysis NR&M G/stn 003303A Blackall

Annual Exceedence Probability (1 in Y years)	Peak Discharge (cumecs)	Monte Carlo 90% quantile probability limits		Peak Level (m Gauge Datum)	Estimated Peak Level (m AHD) at NR&M Gauge
10	682	372	1576	5.80	
20	1359	625	4631	7.42	
50	3130	1076	18915		282.5
100	5652	1516	54823		283
200	9950	2038	157133	See Note 5	
500	20386	2909	618262		

BoM Gauge
036155

Estimated height (m) BoM Gauge	BoM Flood Classifications Minor (2 m) Moderate (4 m) Major (5 m)
4.8	Moderate
6.5	Major
7.5	Major
8	Major

Gauge Zero
275.030 m AHD

Within gauged values
Based on theoretical data ie extrapolated rating curve

Note - Use this data with extreme caution -:

1. The highest gauging was 700 cumecs, so flows exceeding 700 cumecs were estimated using an extrapolated rating curve. Also data above 604 cumecs is poor.
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4. Peak Levels are to the gauge datum Gauge Zero at 274.069 m AHD
5. No data is available as these values are beyond the extent of the rating curve and detailed cross section
6. The levels only apply at the location of the gauging station

The highest recorded flood event of April 1990 has an estimated AEP of 1in 25 years.

Queensland Reconstruction Authority
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Queensland Reconstruction Authority

Points of interest
Roads
Rail
BOM gauging station
NRM gauging station
Cadastre

Depth (m)
0 - 0.5
0.5 - 0.8
0.8 - 1
1-2
>2

Local Authority: Blackall Tambo Regional Council
Locality: Blackall
Datum: Horizontal- Geocentric Datum of Australia 1994 (GDA94)
Projection: Horizontal- Geocentric Datum of Australia 1994 (GDA94)

0 100 200 300 400
Metres
Scale at A3 - 1:14,000

Flood Investigation Level 2
Map 5 Blackall
Draft Indicative Extent and Depth of Estimated Flood AEP 1 in 20 yrs
[6.5m at BOM Gauge # 036155]

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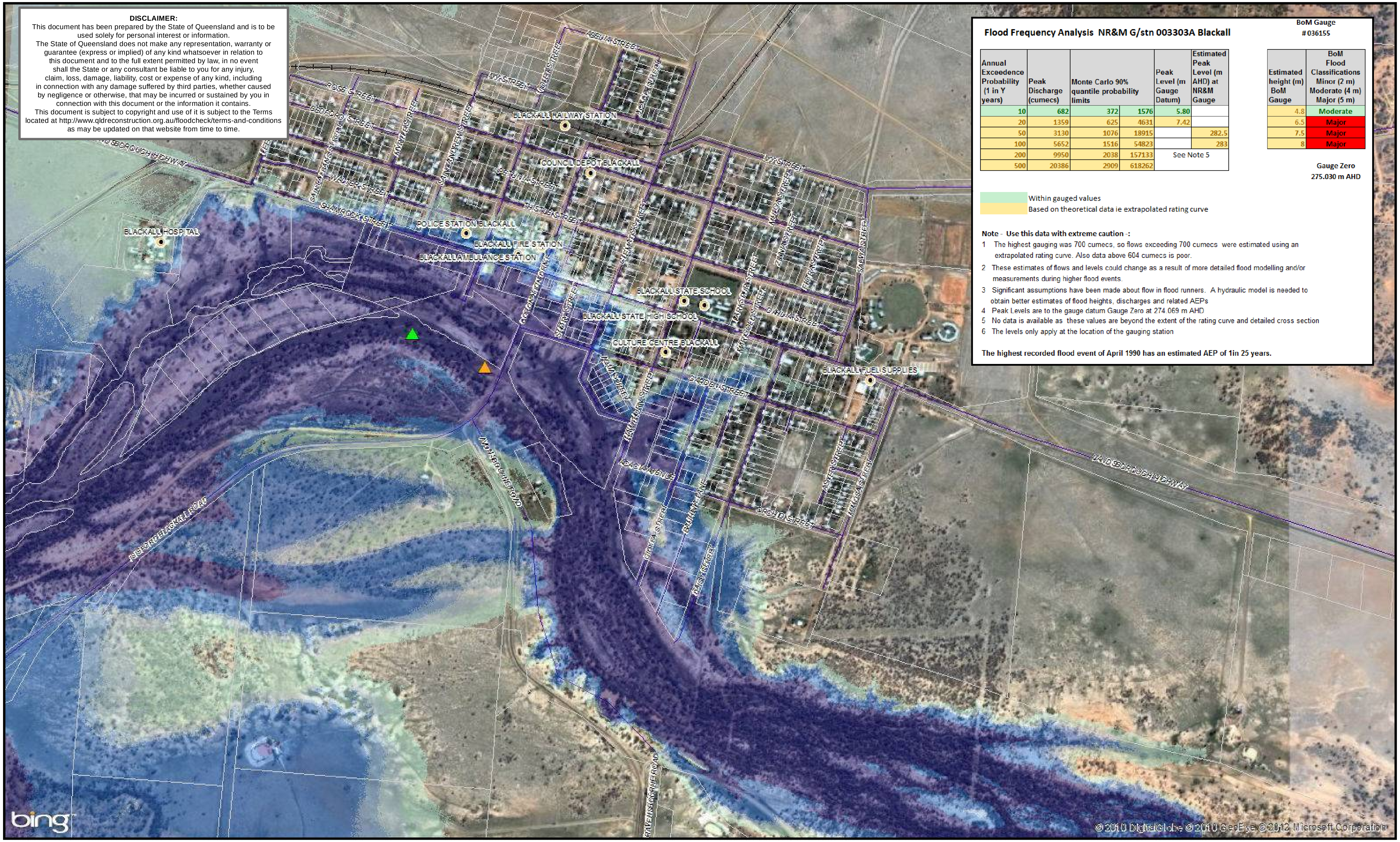

Flood Frequency Analysis NR&M G/stn 003303A Blackall

Annual Exceedence Probability (1 in Y years)	Peak Discharge (cumecs)	Monte Carlo 90% quantile probability limits		Peak Level (m Gauge Datum)	Estimated Peak Level (m AHD) at NR&M Gauge
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200	9950	2038	157133	See Note 5	
500	20386	2909	618262		

BoM Gauge
036155

Estimated height (m) BoM Gauge	BoM Flood Classifications Minor (2 m) Moderate (4 m) Major (5 m)
4.8	Moderate
6.5	Major
7.5	Major
8	Major

Gauge Zero
275.030 m AHD

Within gauged values
Based on theoretical data ie extrapolated rating curve

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The highest recorded flood event of April 1990 has an estimated AEP of 1in 25 years.

Queensland Reconstruction Authority
1800 110 841
www.qldreconstruction.org.au
Queensland Reconstruction Authority

Points of interest
Roads
Rail
BOM gauging station
NRM gauging station
Cadastre

Depth (m)
0 - 0.5
0.5 - 0.8
0.8 - 1
1-2
>2

Local Authority: Blackall Tambo Regional Council
Locality: Blackall
Datum: Horizontal- Geocentric Datum of Australia 1994 (GDA94)
Projection: Horizontal- Geocentric Datum of Australia 1994 (GDA94)

0 100 200 300 400
Metres
Scale at A3 - 1:14,000

Flood Investigation Level 2
Map 6 Blackall
Draft Indicative Extent and Depth of Estimated Flood AEP 1 in 50 yrs
[7.5m at BOM Gauge # 036155]

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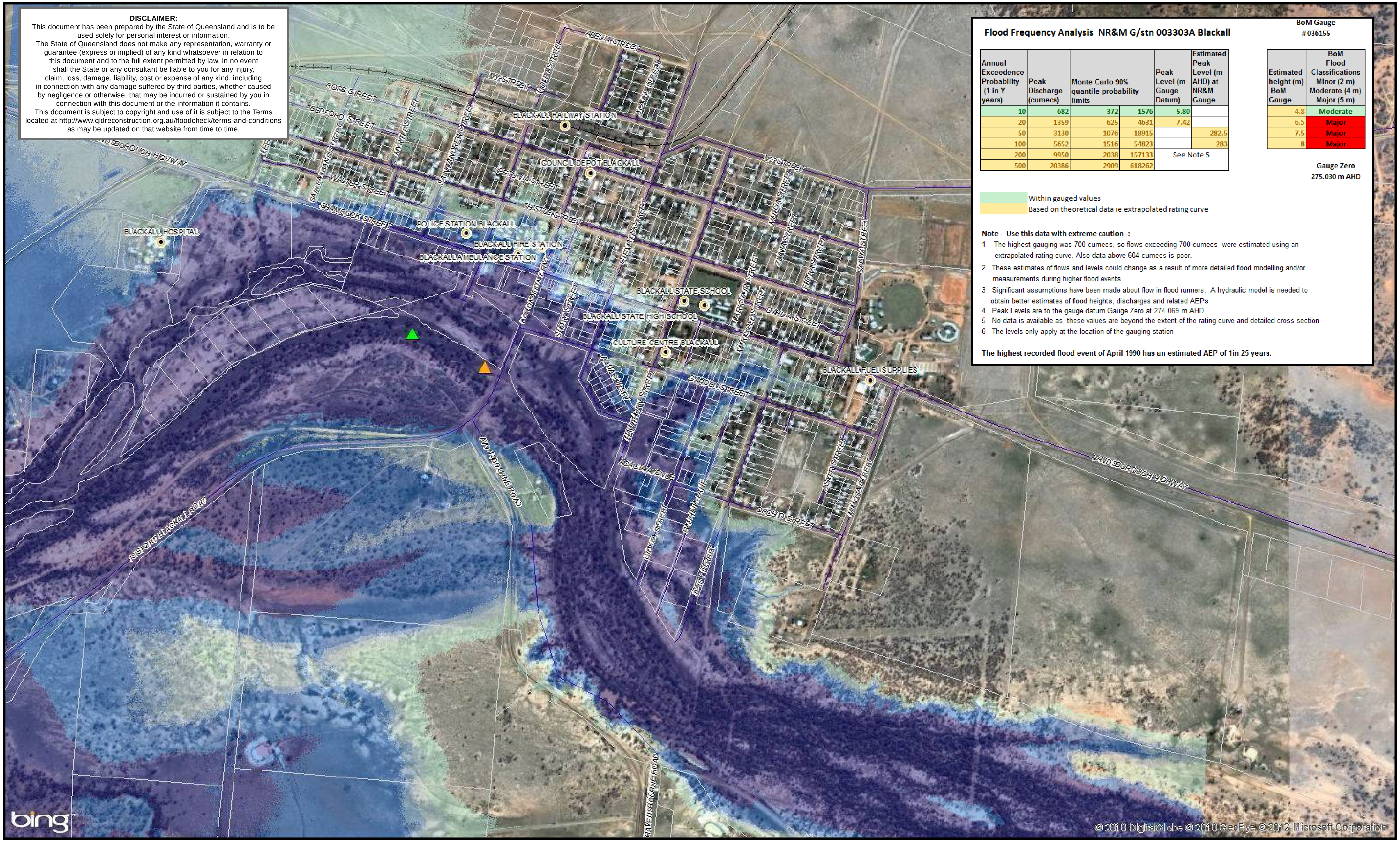

Flood Frequency Analysis NR&M G/stn 003303A Blackall

Annual Exceedence Probability (1 in Y years)	Peak Discharge (cumecs)	Monte Carlo 90% quantile probability limits		Peak Level (m Gauge Datum)	Estimated Peak Level (m AHD) at NR&M Gauge
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100	5652	1516	54823		283
200	9950	2038	157133	See Note 5	
500	20386	2909	618262		

BoM Gauge #036155

Estimated height (m) BoM Gauge	BoM Flood Classifications Minor (2 m) Moderate (4 m) Major (5 m)
4.8	Moderate
6.5	Major
7.5	Major
8	Major

Gauge Zero 275.030 m AHD

Within gauged values
Based on theoretical data ie extrapolated rating curve

Note - Use this data with extreme caution -:

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The highest recorded flood event of April 1990 has an estimated AEP of 1in 25 years.

Queensland Reconstruction Authority
1800 110 841
www.qldreconstruction.org.au

Points of interest
Roads
Rail
BOM gauging station
NRM gauging station
Cadastre

Depth (m)
0 - 0.5
0.5 - 0.8
0.8 - 1
1-2
>2

Local Authority: Blackall Tambo Regional Council
Locality: Blackall
Datum: Horizontal- Geocentric Datum of Australia 1994 (GDA94)
Projection: Horizontal- Geocentric Datum of Australia 1994 (GDA94)

0 100 200 300 400
Metres
Scale at A3 - 1:14,000

Flood Investigation Level 2
Map 7 Blackall
Draft Indicative Extent and Depth of Estimated Flood AEP 1 in 100 yrs
[8.0m at BOM Gauge # 036155]

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11/10/2012
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Appendix D

BLACKALL TAMBO REGIONAL COUNCIL FLOOD MAPPING VALIDATION CORRESPONDENCE

Blackall-Tambo
Regional Council

Exploring the past. Innovating the future.

Blackall-Tambo Regional Council

6 Coronation Drive, BLACKALL QLD 4472
PO Box 21, BLACKALL QLD 4472

P: (07) 4621 6600
F: (07) 4657 8855
admin@btrc.qld.gov.au

www.btrc.qld.gov.au

ABN: 42 062 968 922

AS:as
Enquiries: Ken Timms

5 June 2013

Ms Christine O'Brien
DC Solutions
PO Box 601
LONGREACH QLD 4730

Dear Christine

RE: QUEENSLAND RECONSTRUCTION AUTHORITY'S FLOOD INVESTIGATION FOR BLACKALL

On behalf of the Blackall-Tambo Regional Council I would like to assure DC Solutions and Yarramine Environmental, the project team undertaking the Barcoo River Flood Preparedness and Mitigation Project, Council has complete confidence in the data supplied by the Queensland Reconstruction Authority.

After an examination of the maps and reports resulting from this investigation which were supplied to Council and subsequently to DC Solutions, Council confirms the flood lines and levels indicated are correct and consider that the project team can use this information with confidence.

Yours faithfully

KL Timms
CHIEF EXECUTIVE OFFICER

Appendix E

CASE STUDY REPORT

ATTRIBUTION STATEMENT

Case study material presented in this study has been compressed and summarised from three reports which are available in the public domain. The authors of these reports are therefore the authors of the case study materials from Emerald, Charleville and Mackay. The Lockyer Valley and St George material are based on Tetsuya Okada's ongoing PhD research project.

The Emerald case study is reproduced from a National Climate Change Adaptation Research Facility (NCCARF) funded project:

> Bird, D, King, D, Haynes, K, Box, P, Okada, T, Nairn, K (2013) Impact of the 2010–11 floods and the factors that inhibit and enable household adaptation strategies, National Climate Change Adaptation Research Facility, Gold Coast, 153pp.

The Mackay and Charleville case studies are taken from a National Climate Change Adaptation Research Facility (NCCARF) funded project:

> Apan, A, Keogh, DU, King, D, Thomas, M, Mushtaq, S & Baddiley, P 2010, The 2008 Floods in Queensland: A Case Study of Vulnerability, Resilience and Adaptive Capacity, National Climate Change Adaptation Research Facility, Gold Coast, 171pp. ISBN: 978-1-921609-18-3

Part of the literature review is taken from the following National Climate Change Adaptation Research Facility (NCCARF) funded project:

> King D, Ginger J, Williams S, Cottrell A, Gurtner Y, Leitch C, Henderson D, Jayasinghe N, Kim P, Booth K, Ewin C, Innes K, Jacobs K, Jago-Bassingthwaighte M & Jackson L (2013) Planning, building and insuring: Adaptation of built environment to climate change induced increased intensity of natural hazards. National Climate Change Adaptation Research Facility, Gold Coast, 361 pp. ISBN: 978-1-921609-75-6

The full reports can be found at: http://www.nccarf.edu.au/publications

Lessons from the past: Exploring flood risk reduction through a selection of Australian Case Studies

Report for DC Solutions

David King[1], Tetsuya Okada[2], Katharine Haynes[2], Deanne Bird[2] and Rob Van den Honert[2]

[1] Centre for Disaster Studies, James Cook University
[2] Risk Frontiers, Macquarie University

August 2013

Lessons from the past: Exploring disaster risk reduction through a selection of Australian Case Studies

Table of Contents

Lessons from the past: Exploring disaster risk reduction through a selection of Australian Case Studies

Executive Summary

The five case studies illustrate approaches that may fall into Protect, Accommodate or Retreat strategies.

The research results provide a great deal of valuable information on the barriers and opportunities people face in making changes to reduce their vulnerability to floods prior to, during and after an event. The main factors that were identified as either enabling or inhibiting response, recovery and / or adaptation are:

Direct experience - many people stated that the history of flood events, the inconvenience and stress associated with being flooded and the pain and heartache that the floods caused were significant factors driving their desire to reduce their vulnerability.

Outcome expectancy –the need to protect family members, belongings and assets and, a desire to have peace of mind, were positive drivers in changing behaviour to reduce flood risk. In contrast, others could not comprehend how changes will prevent a disaster occurring from a natural event.

Communication and information - the most widespread series of responses called for more communication and more information prior to and during the flood, which suggests that residents are more willing to adopt reactive strategies rather than proactive measures.

Governance and physical protection – respondents perceive that more dams, better control and management of dams and the construction of levees will help to reduce their flood risk. Other governance issues related to planning and development, building regulations and information.

Insurance - in all communities respondents cited the slowness of obtaining insurance payouts as a barrier to recovery. There was a great deal of anger directed towards the attitudes of insurance companies, the quality of the assessment process, and a lack of clarity in relation to what was covered. Moreover, there was little or no immediate support coming from the insurance industry to assist people to make changes to reduce their risk.

Financial restraint and relief assistance - those people who were not covered by insurance are very limited in their capacity to make changes to their homes due to a lack of funds. Compounding the insurance issue was the fact that many people were not eligible to receive financial assistance from sources such as the Premiers Flood Appeal.

Housing: including design/construction, rental properties, builders and guidance - residents felt they had no options to make changes to reduce their future risk due to the structural design of their home and/or the fact that they resided in a rental property. Respondents cited 'slab-on-ground' constructions as the main reason for not being able to make changes because raising their home was simply not an option.

Health and wellbeing - health impacts, both physical and mental, were identified, leading to problems in recovery.

Relocation – while some respondents suggested that they would consider relocating to a safe location, the dominant response is that people do not consider that it is likely they will move. This reflects resilience and community strengths.

Volunteers and community initiatives - positive and negative aspects of volunteerism were cited. It was recognised that people felt a need to volunteer, in order to do something, but there were problems of a lack of control and some inappropriate assistance. A strong impression from the case study responses was the willingness of residents to get on with their own recovery and to make improvements to reduce the flood risk in the future.

There were a number of findings that relate to planners and local government.

- The first step to an overhaul of land use planning in hazard vulnerable areas is detailed knowledge and mapping of all hazard zones, within which it is essential to model changes that may be expected from extreme events and climate change. All hazard zones must be mapped in sufficient detail to inform planning development assessments and decisions. This process has been ongoing for at least the last decade and that much work remains to be completed. The Queensland Flood Commission of Inquiry recommended the completion of comprehensive flood studies, ideally in whole catchments, but at least in all urban areas.
- The Queensland State Planning Policy 1/03 has not been effective in guiding land use planning in vulnerable locations. It is currently under review, but clearly must be made much stronger in its scope, its requirements and its reporting/referral procedures.
- There is a lack of agreement or consensus amongst planners in response to FCI recommendations concerning: Land swaps and buybacks of properties in highly hazard vulnerable locations; Retreat or relocation strategies; The use and usefulness of defined flood levels such as the Q100; Regulation and construction of hazard protection measures such as levees; The level of government responsibility and funding for hazard mitigation and related activities.
- Planners are strongly in favour of: Whole of catchment flood mapping, Climate change adaptation as part of hazard mitigation, Zones of limited or constrained development, and Flash flooding.
- Local government councils should be responsible for the development of a floodplain management plan.
- Floodplain management plans should adhere to best practice guidelines.
- Comprehensive flood studies should be carried out in all local government areas in Queensland.
- Comprehensive flood studies must take into account the likely impacts of climate change on future floods.
- Comprehensive flood studies should be carried out within the context of the whole catchment.
- Planning schemes should be amended immediately as better flood information becomes available, or if development results in a change to flood risk hazard zones.
- All areas of future urban growth should be mapped for three or more levels of flood risk.
- All local government area flood mapping should be accessible to members of the public on a web site or as printed maps.
- The flood risk to all individual properties and parcels of lands should be made available to the public.
- Community infrastructure must be able to function effectively immediately after a flood or any other kind of natural disaster.
- Planning schemes should contain flood and stormwater policy that sets out information to be provided in development assessments.
- Because overland flow paths are primarily conduits for flash floods these must be mapped as part of overall flood risk assessment.

A dominant finding from these studies is that a greater number of constraints inhibit adaptation than factors that enable adaptive change and behaviour. However, balanced against the criticisms and fault identification the studies show resilient communities getting on with their lives and largely driving recovery themselves. The extensive qualitative comments and opinions garnered from interviews and questionnaires reflected high levels of acceptance of catastrophe and stoic endurance. This does not necessarily translate to adaptation to future events and a changed hazard landscape, but it does reflect strong resilience in the community. That resilience can be built on to advance adaptive behaviour, but it needs to be nurtured and facilitated by external agencies.

Project objective and scope

The aim of the project was to carry out desktop case study investigations into how local communities have prepared for, managed, recovered from and also reduced their risks from future disaster. Text in the literature review, Charleville, Mackay and Emerald case studies has been cut, pasted, edited and modified from three research reports carried out under the National Climate Change Adaptation Research Facility (NCCARF) funding scheme. If reference to the studies is to be made in a public access document, the original NCCARF report should be cited. The intent of NCCARF funding was to generate research results that would be useful to policy makers and government. This summary report has been compiled with that principle in mind. The Lockyer Valley and St George case studies were written by Tetsuya Okada and drawn from his PhD research.

Case study areas

The following case studies have been explored.

- Flooding in Charleville (2008)
- Flooding in Mackay (2008)
- Flooding In Emerald (2011)
- Flash flooding in Grantham and the Lockyer Valley (2011)
- Flooding in St George (2010, 2011, 2012)

The five case study areas chosen are all rural/regional towns in Queensland recently affected by flooding. The consulting team has conducted research, including surveys and interviews with residents and Council management, in each of the above areas, and the results of this research forms the basis of the case studies.

The five case studies were chosen as together they explore a range of issues that address the following points:

- the role of organisations involved
- an analysis of disaster preparedness
- responses employed in the aftermath of disaster,
- success factors associated with transitioning communities from response to recovery, and
- risk reduction measures undertaken by individuals and governments.

Charleville and Mackay document and focus on the response and recovery measures undertaken and the roles of different organisations involved in these efforts. Grantham and St George, explore the risk reduction measures instigated by government to reduce future risks. The consultants decided to include both these case studies as one documents a relocation scheme and the other the use of a levee. Together they provide a comprehensive overview of the use of such measures to reduce risks. Emerald investigates the factors which inhibit and enable individual risk reduction measures at the household level. This case study therefore explores the issues and likely outcomes when there is limited involvement from government.

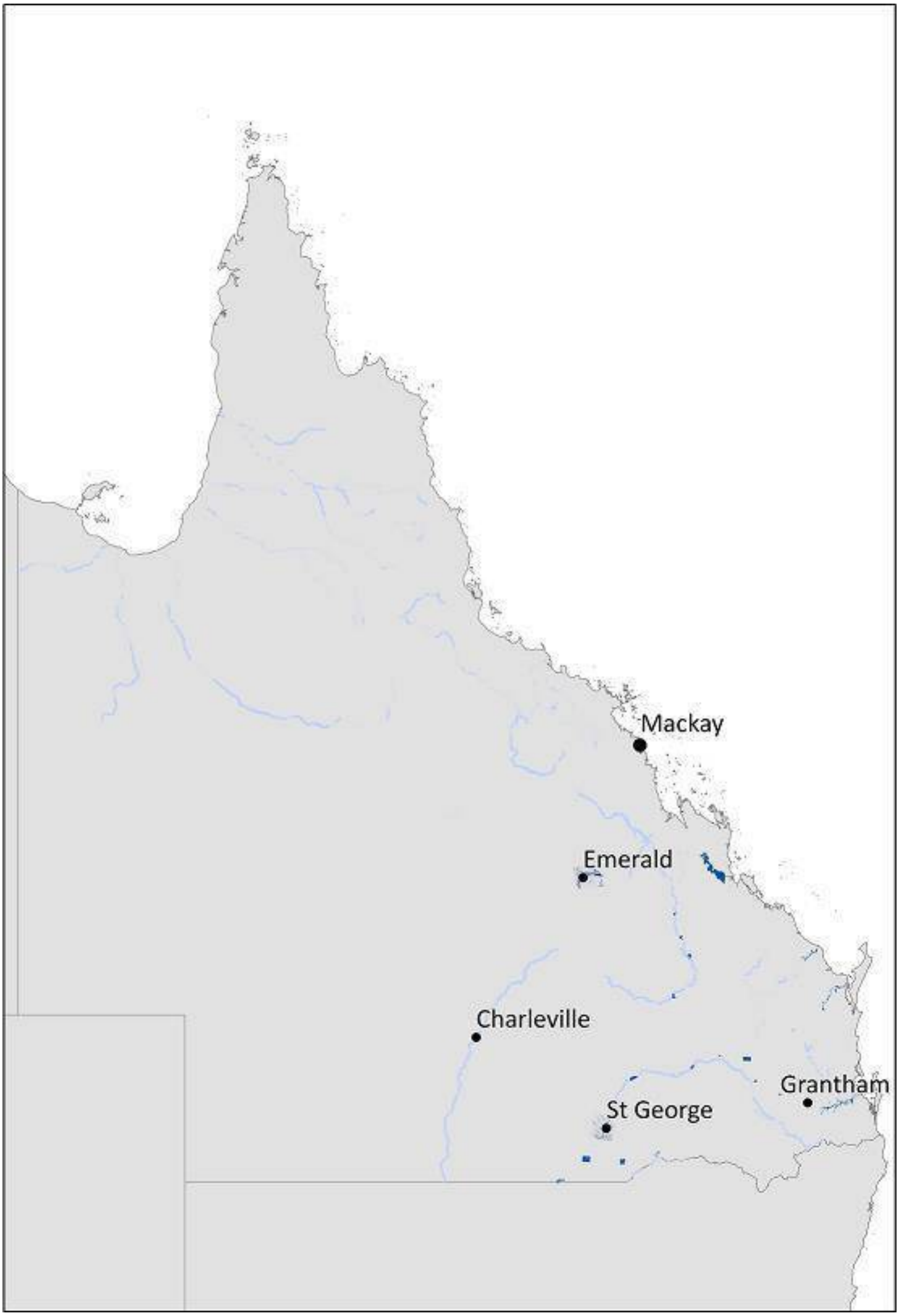

Figure 1: *Case Study Locations*

Review of Australian and International experiences of natural hazards.

(The following literature review is compiled and reproduced from reviews written by D.King and D.Keogh in three NCCARF studies that have provided case studies used in this review: Apan et al 2010, Bird et al 2013 and King et al 2013.)

International flood studies have highlighted insights into public and decision-maker levels of understanding about flood information and their behaviour. For example, in the October 1988 flood in Nimes, France, which damaged the homes of 45,000 residents, a community survey revealed that only 17% of interviewees were aware that they lived in an area that is subject to flood (Duclos et al., 1991).

Krasovskaia et al. (2001), in their study of the perception of flood risk by decision-makers in Norway, found that the perception of flood hazard by the general public was poor. They found that if given an order to evacuate, less than half their public respondents would obey such an order immediately and about one third would wait and see what transpires. This study found that amongst decision-makers, there was poor insight about the economic issues of measures to prevent floods, and there was difficulty visualising the likely costs and results of actions associated with approaches that can be used to reduce floods.

In the City of Carlisle, England 70% of small businesses impacted by the 2005 flood were unable to recover despite having sufficient levels of flood insurance (Sivell et al., 2008), because their customers had found alternate sources of supply by the time they recovered from the physical impacts of the flood.

Bell and Tobin (2007) identified problems between the concepts of persuasion and understanding, when they investigated levels of understanding relating to four terms used in US policy's benchmark flood. Their study investigated residents living both within and outside an official flood plain area. They studied four descriptive methods that were used: "*a 100-year flood"*, "*a flood with a 1% chance of occurring in any year"*, "*a flood with a 26% chance of occurring in 30 years"*, and "*a flood risk map"*. They found disjuncture between the concepts of understanding and persuasion, and problems with the descriptive method that used certain terms. For instance, the description of a flood that has a 26% chance of occurring in 30 years "*induced confusion, vehemence, and dismissal*" among the sample of residents. They also found that respondents preferred definitive references for describing risk, such as damage estimates in dollar terms. Bell and Tobin (2007) found that participants were more concerned about the level of the flood than its frequency, and were more easily persuaded when they were provided with specific physical references and examples which were concrete, as opposed to abstract, such as damage estimates. This was also found in studies by NRC, 1995, 2000, 2006; Smith, 2000; Siegrist and Gutscher, 2006; ASFPM, 2007.

The reasons for warning failures have been investigated by Handmer (2000) who classified these according to whether shared meaning was achieved between the issuing authority and the public. Reasons could relate to impediments such as language barriers, the public not receiving the warning, lack of mobility options, an individual's attitude to risk, a lack of faith in the warnings, and the impact of false alarms on future evacuations (Pfister, 2002).

Understanding how floods impact upon communities gives insights and structure to strategies and policies aimed at reducing or mitigating the impact of future flood events. Places that are frequently flooded have had to deal with disastrous events as a regular pattern of the seasons. As climate change scenarios predict an increase in extreme rainfall events, contributing to a greater frequency of riverine and flash floods (IPCC 2007a) the experience of regularly flooded communities in preparing for and dealing with such events provides information to planners and emergency managers, and an understanding of flood adaptation for communities that have a greater flood risk in the future. Regularly flooded communities can be seen as an analogue for other places that have to make similar responses and adaptations in the future.

A study by Pfister (2002) of the March 2001 flood in Grafton, NSW, found that successful evacuation depends on the readiness of the public to respond to a warning issued to evacuate. The study concluded that the Grafton residents were not ready to evacuate, did not have a realistic appreciation of the threat of flood, generally did not accept that there was a need to evacuate, and did not understand the evacuation strategy (Pfister, 2002).

Levee protection can create a sense of invulnerability in a community which is not unjustified (Keys & Campbell, 1991; O'Brien & Payne, 1997). Communities also often believe that a flood will not exceed the record of the previous flood, as Heatherwick (1990) found after the April 1990 Charleville flood.

Bell and Tobin (2007) emphasised the importance of investigating the relationship between understanding and persuasion in flood plain management and flood risk communication in order for it to be more effective. For example, community response to flood warnings was reported as being problematic in the March 2001 Grafton floods in NSW when fewer than 10% of the population left the city during the nine hour evacuation (Pfister, 2002). Pfister (2002) suggested that although operational debriefs are important for exploring potential areas for improvement to enable emergency managers to include lessons learned into future operational planning, they generally do not capture the public perspective. This highlights the importance of consulting the public on their experiences, lessons learned, insights post major flood events and possible needs in terms of planning for future events.

Vulnerability, Resilience and Adaptation

Emergency management mitigation issues are structured through vulnerability assessments, resilience and adaptation. Social impact and social capital factors are identified by COAG (2004) and IPCC (2007a) and Adger (2003). Following the UN International Decade for Natural Disaster Reduction, Emergency Management Australia shifted its emphasis for hazard mitigation from vulnerability assessments to a policy of building resilient communities. In establishing the basis for the 2008 Queensland flood studies Apan et al (2010) defined resilience (UN 2007), identifying indicators, scale and component parts such as stability, learning and self organisation (Carpenter 2001, Thomas et al 2005). Individual and collective resilience include elements of adaptive capacity as well as broadly accepted features of social networks, social capacity and hazard awareness (Eriksen et al 2005,Nelson & Finan 2008, Brown et al 2002).

Vulnerability and resilience are separate, but overlapping conditions. Government emphasis on building resilience is predicated on resilience attributes representing strengths in people and society that may be built upon or enhanced as hazard mitigation strategies. The difficulty with vulnerability assessment is the lack of capacity of individuals or communities to be able to do much about altering or improving structural vulnerability, such as demographic (the very young and very old), poverty, ethnicity, lack of education etc. It is valuable for authorities to assess vulnerability so that they may be better prepared for hazard impact, but community response is limited in dealing with most elements of vulnerability. While some resilience characteristics are at the opposite end of the scale to vulnerability, many are of different aspects of community or of peoples' lives, such as social networks, volunteerism, previous hazard experience and so on. It is for this reason that resilience is targeted at strategies of hazard mitigation, building on the existing strengths of the community. However, in assessing the resilience of a community we have to balance it with the existing vulnerability. The state of vulnerability does not necessarily reduce any particular characteristic of resilience, but the balance of the two states -- positives and negatives -- has a potent impact on the capacity to mitigate impacts of natural hazards. This may in turn influence the capacity of an individual or community to adapt to a changing state of natural hazard occurrence or severity.

Underlying factors of both vulnerability and resilience also involve regional governance and economy (Sivell et al 2008).

The concept of resilience has shifted from a simple capacity to bounce back (EMA 2011) that indicated the capacity to recover from the disaster. As resilience has been mainstreamed as a strategy to reduce the impact of disasters its importance has called for many and precise definitions, the identification of factors of resilience and their measurement (Zhou et al 2010, Folke 2006). The development of resilience in emergency management has incorporated social ecological systems (Folke 2006), as well as psychological factors (Werner 2000). In particular resilience is identified at a range of levels; including the individual (Bonnano 2004), community (Kulig 2000, Adger 2000, Paton & Johnston 2001), institutional and organisational or governance sectors (Cutter et al 2008).

Implicit within resilience at all levels is the idea of change. People and communities do not just bounce back after a disaster. Some features and institutions have gone and new opportunities, people and structures enter into the community. Recovery, which builds on characteristics and resilience, moves on to a different state. The community hardly ever returns to its pre-disaster state. Rather than being pushed along by changes that it does not control a resilient community must encompass adaptation as a process of transition and transformation (Pelling 2011). It follows that the emergency management strategy of building resilient communities is dynamic in encouraging and facilitating social and organisational change, to adapt to the need to prepare for repeated disasters as well as new levels of hazard.

Pelling's (2011) idea of adaptation as resilience is developed from the disaster and social ecological systems literature, but emergency management practice remains heavily influenced by the idea of a return to functioning normality, even if emergency managers do acknowledge that nothing is ever the same after a disaster. Also emergency management practice puts a great deal of emphasis on education, learning and social transformation to a more aware and better prepared society.

Resilience is not static. A truly resilient community must possess the capacity to absorb, encompass and action change. Some aspects of community strength, such as a strong sense of place, stoicism and coping capacity reduce vulnerability and contribute to resilience, but on their own (and there are many other similar kinds of community virtues) they may reinforce conservative attitudes that reject change. There are levels or types of resilience, some of which are less conducive to adaptation and change; for example stability resilience, recovery resilience and transformational resilience.

Pelling (2011) presents pathways to adaptation which range from bottom-up to top-down processes of change. As a whole of government, whole of community responsibility climate change adaptation must take place at all levels. Different strategies and approaches will operate in parallel or even together. The process is more important than perceived outcomes, as specific goals or targets once achieved may bring about an end to an adaptation strategy, resulting in complacency and stagnation.

Protection, Accommodation and Retreat

Titus (1991) suggested that hazard mitigation and climate change adaptation strategies fell under three approaches of protection, accommodation or retreat. Protecting communities with physical structures had long been a practice, in many parts of the world. Accommodation as a means of educating people and authorities to be better prepared and to take mitigation actions received a boost during the UN's International Decade for Natural Disaster Reduction that put emphasis on community and social actions during the 1990s. The retreat strategy is more controversial and may be constrained by legislation that requires compensation for property loss or change of use (Titus 1991). However, the Department of Climate Change (Department of Climate Change 2009, Alexander et al 2011) adopted a practical open-ended strategy of protect, accommodate or retreat. Each of these three approaches provides a range of actions, plans and choices for all levels of