THINK OR SWIM – PLANNING DEVELOPMENTS SO LIFEBUOYS AREN'T NEEDED

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Abstract
What do you do when a proposed development would place 14,000 people on a floodplain where the flood of record is 1.5m higher than the 1 in 100 flood? Have a well thought out flood evacuation plan and the infrastructure to support it.

The proposed Penrith Lakes Development may see 400 hectares of urban development and 700 hectares of regional parkland built on an alluvial floodplain on the Nepean River a couple of kilometres downstream of Penrith.

While it is possible to construct residential floor levels above the 1 in 100 flood level, there is evidence of much higher floods which would completely overwhelm the development, making complete evacuation beforehand essential. Furthermore, commercial activities in the parklands could take place at much lower levels.

This paper explains:

- how the public safety issue was analysed;
- what planning controls and infrastructure were proposed to facilitate planned evacuation by the SES;
- what further measures were proposed to reduce risk to life; and
- how integration with regional evacuation planning was considered

Background

In 1979 the NSW Government reached an agreement with a consortium of resource companies which gave them permission to extract sand and gravel from an alluvial floodplain of the Nepean River, approximately 3 km north of the Penrith City Centre.

The requirements for closure of the extraction operations included the creation of recreational lakes, regional parkland and some urban development. Work was partially completed with the creation of the Regatta Lake which was used for rowing, canoeing and kayaking events at the 2000 Olympics and is used for recreation and competition today.

The final development proposal, which is currently being considered by the Department of Planning, consists of up to 410 hectares of urban development, 700 hectares of lakes, and 800 hectares of parkland.

Penrith Lakes urban development would include 4,900 residential lots as well as a commercial centre and an employment precinct creating an estimated 2,600 permanent jobs.

A possible development concept is shown in Figure 1.

Flood Hazards

Like any other quaternary alluvial deposit, the Penrith Lakes precinct is susceptible to flooding. The range of floods and their likelihood were not fully understood when the initial agreement was made in 1979.

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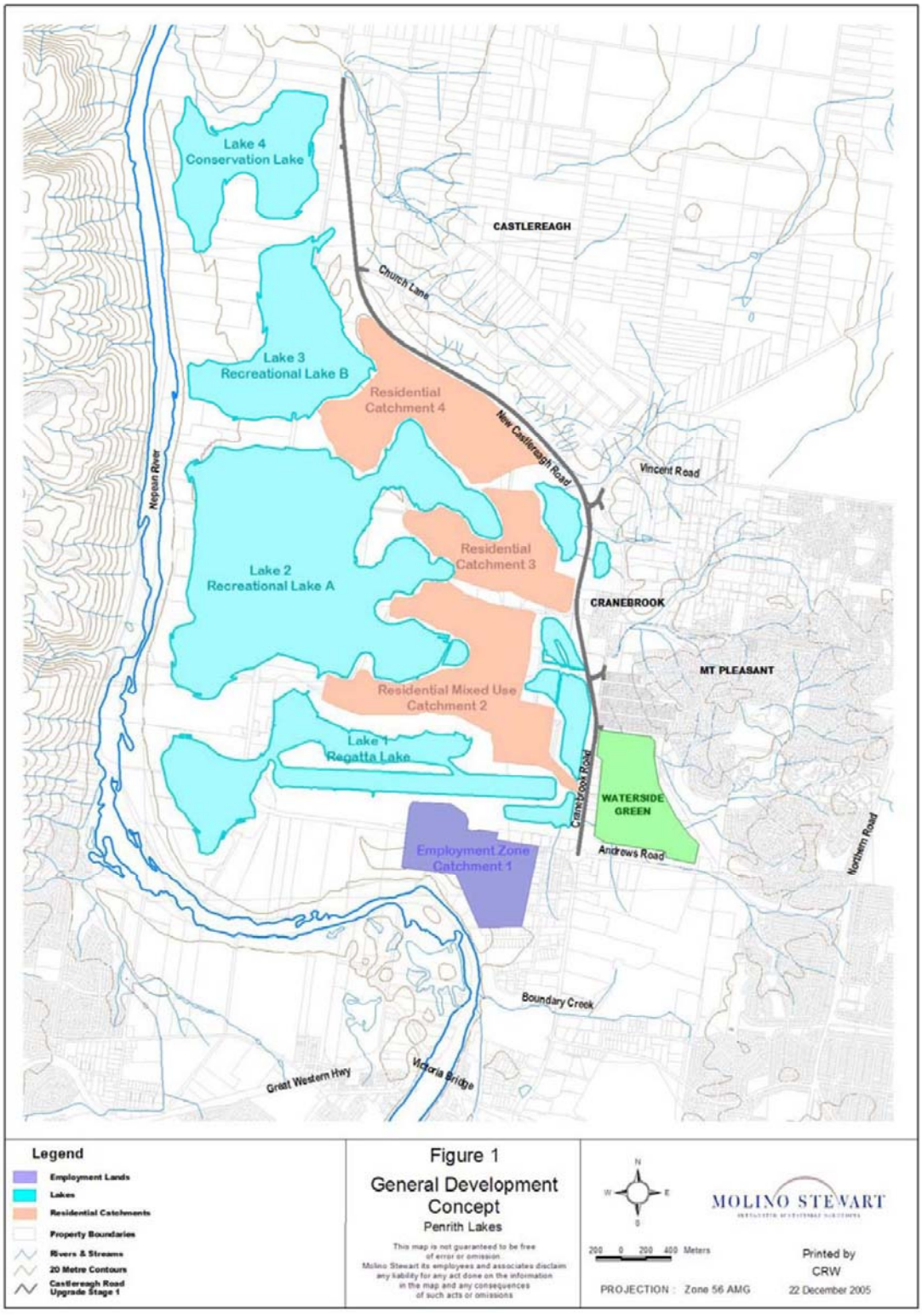
Figure 1: Possible Development Concept



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However, extensive investigations associated with the safety upgrade of Warragamba Dam revealed that the 1 in 500 AEP flood would be a metre higher than the 200 AEP flood which in turn would be 1.5m higher than the 1 in 100 AEP flood. The probable maximum flood (PMF) would be about nine metres higher than the 1 in 100 AEP flood (HNFMAC, 1997).

The flood of record occurred in 1867 and would have been similar to a 1 in 200 AEP event. There is evidence further upstream that at least one flood equal to or exceeding the 1 in 500 AEP event came down the River in the last 3,000 years (Saynor and Erskine, 1993).

The Penrith Lakes Development Corporation (PLDC) constructed a physical model of Penrith Lakes and over the years has extensively tested the interaction of various floods with mining and development concepts.

Figure 2 and Figure 3 show the way in which the 1 in 200 and 1 in 500 floods would affect the development.

As can be seen, the residential areas become isolated islands which diminish in size, and ultimately can disappear as flood levels rise.

Generally, velocities are expected to be quite low as the lakes fill as they have been engineered to fill simultaneously to minimise erosion. In events which completely cover the development, velocities would become much more significant.

Planning Controls

A study in 2003 by Molino Stewart Pty Ltd and Sinclair Knight Merz reviewed estimated flood hazards and risks and made recommendations in relation to planning and building controls and evacuation management.

The results of that study are not the subject of this paper. A development proposal in response by PLDC included residential development as low as half a metre above the 1 in 100 AEP flood level. However, the finished surface levels were such that most of the ground floors would be in the vicinity of the 1 in 200 AEP level.

Critical infrastructure and vulnerable developments such as hospitals and nursing homes will be prohibited within the development

Life Safety Risks

This paper focuses on the life safety risks and ways in which they might be managed. These were considered in the 2003 review and revised by Molino Stewart in 2006 in light of more flood modelling information and the development concept put forward at that time. That concept is being reconsidered in light of the evacuation evaluation.

Figure 2 and Figure 3 show how floods would affect the development concept which was the subject to the 2006 evacuation evaluation. If residents and workers are not evacuated from the area there is a real risk that they will be stranded, and possibly overwhelmed, by floodwaters depending how high they rise.

The first consideration therefore was whether these risks were acceptable. A 1 in 1,000 AEP event would be sufficient to cover the whole site to a depth of a few metres. Loss of life would be a real risk to anyone remaining on site in such an event.

While there are no standards for tolerable loss of life in a flood, it is noted that the Department of Planning guidelines for the siting and design of hazardous industries requires less than a one in one million chance of a fatality per year in a residential area (Department of Planning, 1992).

While this applies to the placement of a hazard near a residential area, I make the point that floodplain development includes

Figure 2: Extent of Flooding in 1 in 200 AEP Flood

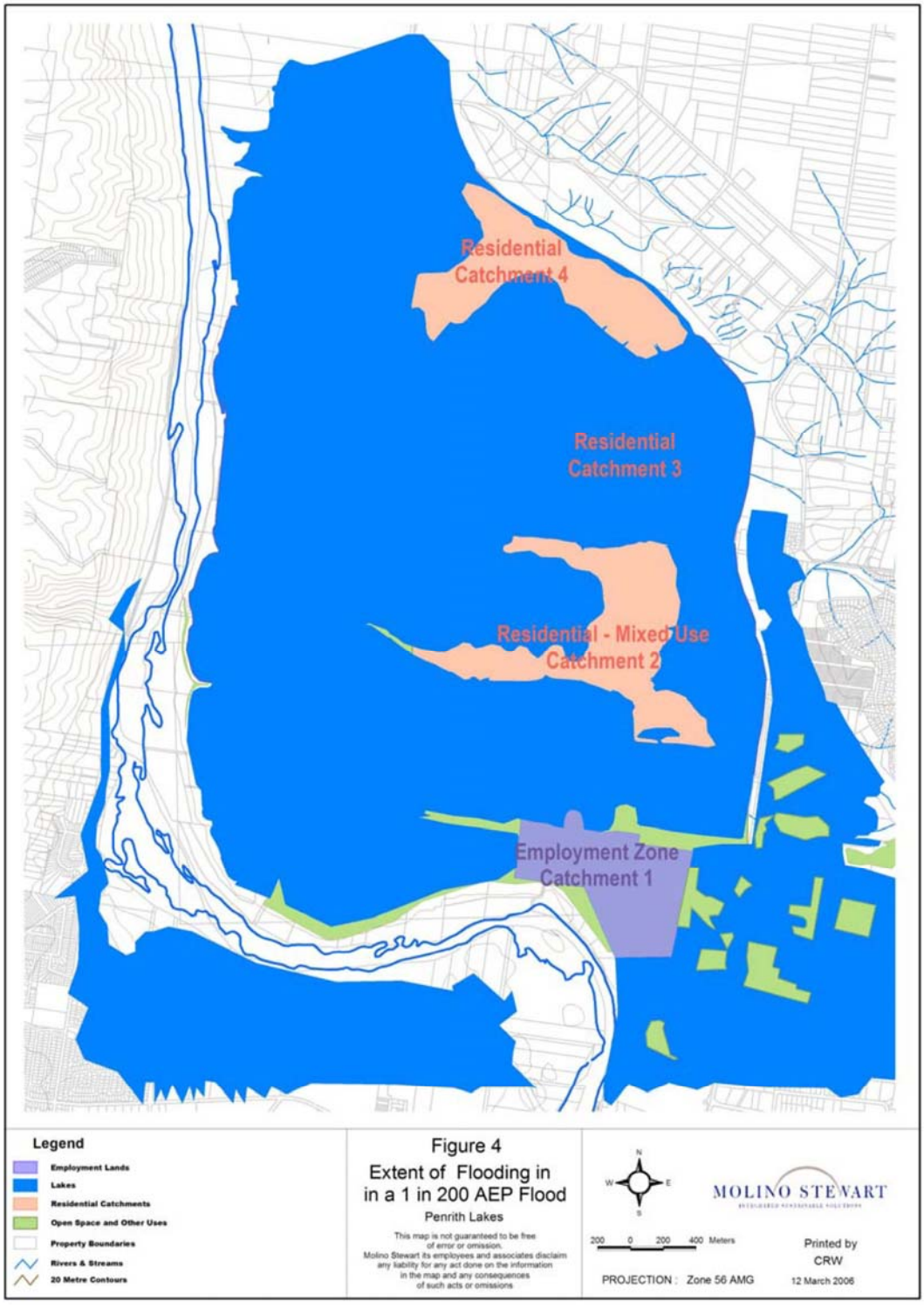
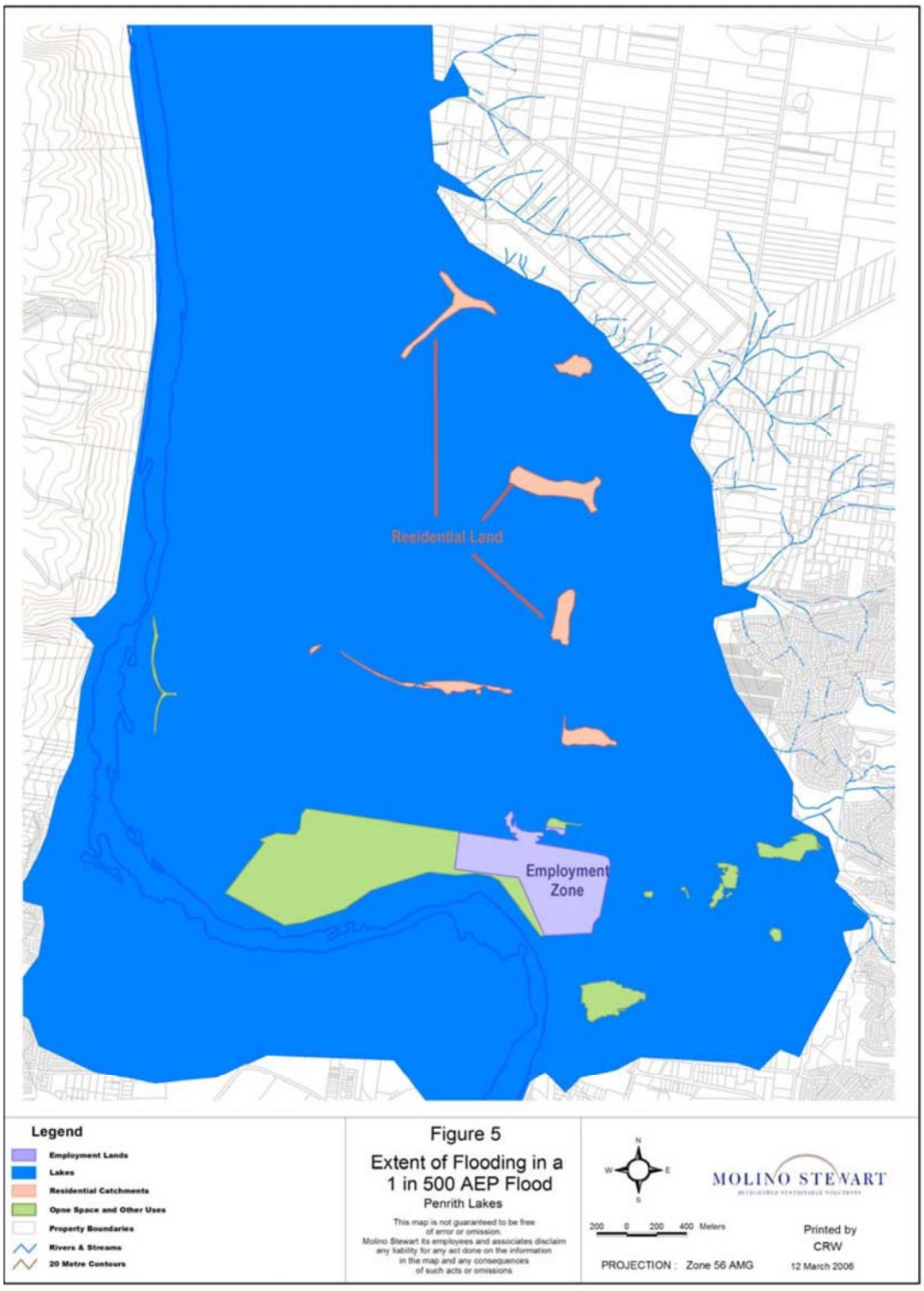


Figure 3: Extent of Flooding in 1 in 500 AEP Flood



the placement of residential areas near a hazard.

The State Government's position is that urban development at Penrith Lakes may only proceed if there is safe evacuation and/or other measures in place to protect residents and others in all floods up to the PMF, which at Penrith has about a 1 in 10,000 chance per year of occurrence.

Evacuation Planning

The NSW State Emergency Service has developed a comprehensive plan for evacuating up to 60,000 people from the Hawkesbury Nepean Valley in the event of a significant flood (SES, 2006). Because of the logistics involved and the risk of evacuation routes being cut before population centres are flooded, the SES has developed a timeline model for evacuation planning.

This model compares the time available for evacuation with the time needed for evacuation to determine whether full evacuation is possible. Opper (2004) describes in detail the model assumptions and logic but basically it takes into account the time needed to mobilise emergency service personnel, to doorknock properties, for evacuees to accept the warning message, for them to prepare to evacuate and for them to drive along evacuation routes in poor driving conditions. It also includes an allowance for traffic delays due to localised flooding, breakdowns, collisions or fallen trees or power lines.

The time available for warning and evacuation is based on rates of rise from design flood hydrographs plus advice from the Bureau of Meteorology on how much warning it can provide based on forecast rain, fallen rain and recorded streamflows.

Where the time needed exceeds the time available, the deficit can generally be closed by reducing the size of the development, upgrading the evacuation infrastructure or increasing emergency service personnel.

The SES evacuation model focuses on the ability to evacuate the at-risk population out of the flood zone within the time available. Failure to do so however, is only one measure of potential evacuation failure.

Should everyone be evacuated from the flood zone but have nowhere to go or be gridlocked in on the evacuation routes then the evacuation could be judged to also have failed.

Furthermore, it must be recognised that the vehicular evacuation model necessarily is built on many assumptions. Should the flood, evacuees, roads or emergency service resources perform differently in an actual flood than has been assumed in the model, there is the potential that not all people will be able to evacuate by vehicle.

Plans are therefore needed for the evacuation on foot or the rescue of those people who have not been willing or able to evacuate in accordance with the SES plans.

Penrith Lakes Evaluation

Three evaluations were performed for the proposed Penrith Lakes Development. Each was an iterative process where evaluation results fed back to the developer, SES and the Department of Planning so that adjustments could be made to the proposed development, evacuation infrastructure or evacuation planning.

Vehicular Evacuation

The first consideration was whether the proposed development could be evacuated in accordance with the principles of the Hawkesbury Nepean Flood Emergency State Plan. The SES timeline model was used with the same assumptions which the SES had used for the evacuation planning of existing population centres on the floodplain.

This included the assumption that any flood could rise as fast as the early stages of the 72 hour PMF.

This modelling led to recommendations in terms of maximum development size, distribution of the development over the floodplain, minimum emergency service personnel numbers and minimum number of road lanes and levels along various routes between the development and flood free land.

Pedestrian Evacuation

It was recognised that there are any number of reasons why not everyone would be able to evacuate by vehicular as planned by the SES. The greatest risk is probably that people will simply not respond to the warning message in a timely manner.

This has happened in many locations in recent years including Grafton in 2001 where an estimated 10,000 people were only saved from catastrophe because the flood fell just short of overtopping the levee, contrary to forecasts.

The SES preference is not to have boat rescue as the first contingency should not everyone evacuate by vehicle. Not only does it have inherent risks but the numbers of people that could be stranded at Penrith Lakes would make it impractical. The backup plan was therefore to have people self evacuate on foot. The SES had not developed a model for this scenario so Molino Stewart developed one.

For this evaluation a flood rising as fast as a 24 hour PMF was used which was the fastest rising of all of the design floods modelled. A pedestrian evacuation network was recommended that would allow evacuation from each property along a constantly rising route to flood free land. It was recommended that the gradient was sufficient to allow a person walking at 2kph to constantly remain ahead of the rising floodwaters. Further recommendations were made with regard to building floor levels to reduce the risk of people stepping people stepping out of buildings into deep floodwaters.

Regional Traffic Queuing

For the proposal which was evaluated, once the evacuation traffic from Penrith Lakes left the floodplain it would be directed along The Northern Road to the M4 Motorway. At any one time there are likely to be two streams of evacuation traffic from Penrith Lakes taking up the full capacity of two lanes of the Northern Road.

A recent development adjacent to Penrith Lakes, Waterside Green, would also have to evacuate at the same time and would require a third lane. This could be achieved by constructing an additional lane along the Northern Road or by allow contra flow traffic on one of the two incoming lanes.

A difficulty arises however because The Northern Road is already the designated evacuation route for Richmond and Bligh Park. Traffic from these two locations would arrive at The Northern Road from different directions but converge in the vicinity of where Penrith Lakes and Waterside Green traffic enter The Northern Road.

Were all five traffic streams to arrive simultaneously the maximum three lanes to the M4 would have insufficient capacity and traffic would queue. It was therefore important to understand the likelihood of this happening and the implications were it to occur.

It was not possible to quantify the likelihood of this scenario other than to say it was a realistic possibility. This is because Richmond and Bligh Park are downstream of Penrith Lakes and their floods are influenced by inflows in addition to those which run past Penrith.

It is entirely possible for a flood to run down the Nepean River triggering an evacuation of Penrith Lakes and then move on down to Richmond and Bligh Park. By the time the downstream

evacuees reach The Northern Road all of the Penrith Lakes evacuees will have gone and there would be no traffic queuing.

But should flooding at Richmond and Bligh Park be initially dominated by flows from the Grose River, Colo River or South Creek instead of the Nepean, then Richmond and Bligh Park could be evacuated a bit before Penrith Lakes is evacuated. This is particularly a risk because these downstream centres have a greater chance of having their evacuation routes cut and therefore are evacuated earlier in the evolution of a flood than Penrith.

It was agreed that the worst case scenario would be when all evacuation traffic arrives at the Northern Road simultaneously but no probability could be assigned to this occurring. All that could be said with some certainty is that there is less than a 1 in 100 chance of it happening in any year because a flood of that magnitude would be needed to trigger evacuation of all centres but not every evacuation would result in the worst case traffic convergence.

Were the worst case to occur the implications would be significant. There could be two lanes of queued traffic each over 20 kilometres long with some vehicles being stationary for up to six hours. It is unlikely that this would acceptable even taking into account the probability of the event that would cause it.

Furthermore, queues that long of Penrith Lakes traffic would mostly be on the floodplain which would mean that the safe evacuation of the development had failed. Bligh Park traffic could be accommodated along the evacuation route above the floodwaters only if vehicles were stacked into side streets. Only the Richmond evacuation route has sufficient length outside of the floodplain to accommodate a single 20km queue. Penrith Lakes evacuation traffic would therefore have to be given priority over evacuation traffic from existing population centres were they to converge.

Because the existing evacuation traffic takes up all of the available capacity on The Northern Road, any development at Penrith Lakes has the potential to cause regional evacuation traffic queues.

The alternative, if the queues are to be minimised, is to raise sections of Richmond Road which would provide an alternative evacuation route for Bligh Park such that it would not have to use The Northern Road for evacuation.

Interestingly, such an option may make it possible for additional development to take place at Bligh Park which to date has been capped due to the lack of evacuation route capacity.

Conclusion

When planning new developments in floodplains evacuation evaluation needs to be undertaken if life safety risks are to be kept to a tolerable level.

Using the SES timeline evacuation model can help evaluate whether vehicular evacuation of a development would meet SES criteria. Satisfying those criteria may not be sufficient however if failure to evacuate can result in loss of life.

The ability of pedestrians to walk from buildings to flood free ground on rising evacuation routes is critical if loss of life is to be kept as low as reasonably practical.

The implications of evacuations from new developments on evacuation traffic from existing developments needs to be properly understood and addressed.

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