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FLOODPLAIN RISK MANAGEMENT PLAN AND STUDY

FOR THE WALLSEND COMMERCIAL CENTRE

301015-00768 – 1

August 2009

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FLOODPLAIN RISK MANAGEMENT SYNOPSIS, STUDY AND PLAN FOR THE WALLSEND COMMERCIAL CENTRE

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	For review		DmC		27 Feb 2009	N/A	
B	Reviewed by NCC	lk	BK,LK,DG		23Mar 09		
C	Amended for Adoption after exhibition				4 August 09		

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SYNOPSIS

Flood impacts along Ironbark Creek have been studied for some time, culminating in the 'Wallsend Floodplain Risk Management Study and Plan' issued in draft in March 2007. This 'full study' was targeted at the entire catchment (Wallsend, Elermore Vale and Rankin Park) and recommended a number of options for residential properties along with the Wallsend Business District. To date, approaches to Government to fund these options have been unsuccessful. The current Plan and Study (*this report*) was initiated in response to the June 2007 flood to focus exclusively on developing strategies to manage the risk to life in the Wallsend Commercial Centre should a similar or greater flood event occur.

The location and extent of the Wallsend Commercial Centre, for purposes of this Plan and Study is shown in **Figure 1** below:

Figure 1 - Wallsend Commercial Centre

Both Wallsend Studies will be incorporated into a Management Plan for the entire Newcastle local government area which is being developed over the next eighteen months. However, given that the Wallsend Commercial Centre is particularly at risk from flash flooding, with the numbers of lives potentially at risk in the thousands in a worst case scenario of a severe flash flood occurring on a busy business day, it was decided to expedite planning for this area so that financial support could be sought as a matter of priority for practical options identified in the plan.

There are two parts to this report: a Plan and a Study. The Plan summarises and prioritises the recommended options giving cost estimates and possible funding sources. The key components and responsibilities are also identified. The Plan is based on the findings of the Study which describes and analyses the flood hazards and consequences to the community; assesses possible strategies to address the problems; and determines what strategies are feasible based on impact (time, depth and velocity); cost, and social, economic and environmental consequences.

The Study and Plan have been developed with grant assistance under the State and Federal Floodplain Management Grants Scheme. They have been carried out in accordance with the principles of the NSW Government Floodplain Development Manual *(DIPNR, 2005)* and in accordance with Newcastle City Council's Flood Policy (2004) and Development Control Plan (2005). The development of both the Study and Plan has been informed by the Newcastle Floodplain Risk Management Committee.

The Wallsend Commercial Centre Floodplain Risk Management Plan comprises three elements shown in **Figure 2**

1. **Emergency Management and Flood Readiness** *(Local Emergency Management Committee & Agencies)*
2. **Living with Floods** *(Private Landholders on private land)*
3. **Reducing the risk** *(Government works on Public Land and Planning Controls)*

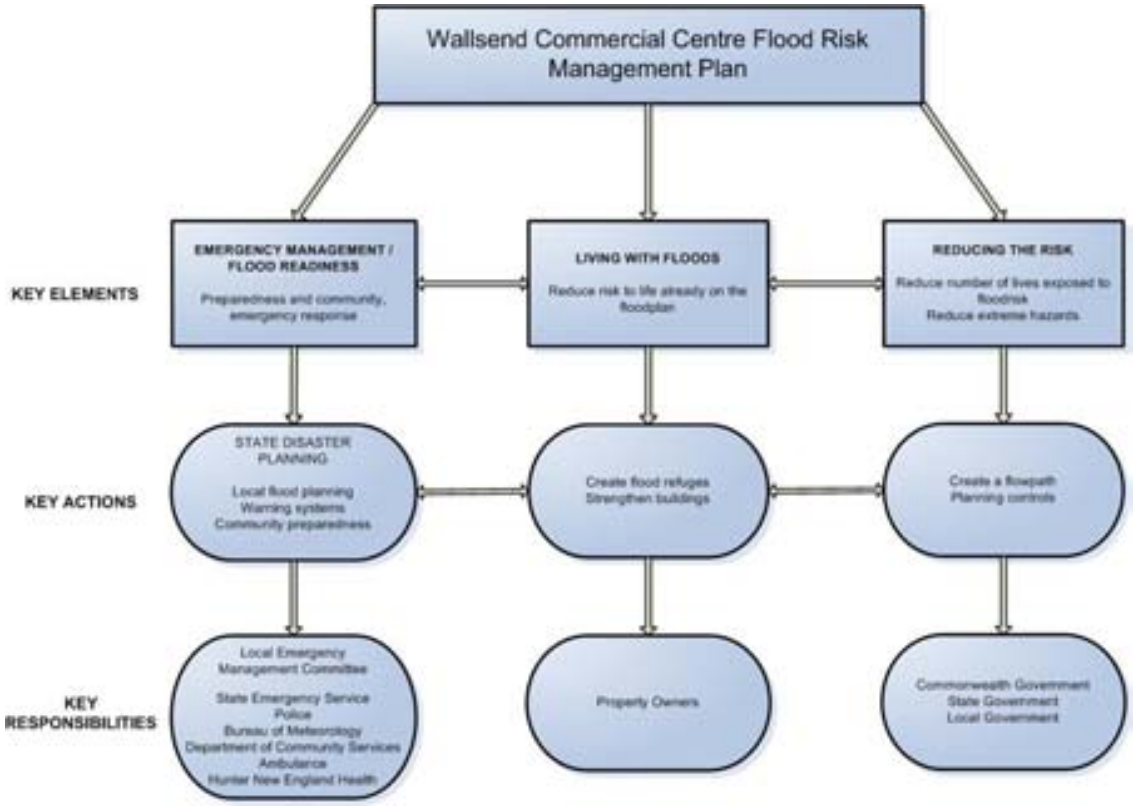


Figure 2 - The Key Elements of the Wallsend Commercial Centre Floodplain Risk Management Plan

Each of these three key elements – Emergency Management and Flood Readiness; Living with Floods and Reducing the Risk - need to come together to reduce the flood risk in the Wallsend Commercial Centre. For example, a flash flood warning system cannot be solely relied on to save people since it is not fail safe and since it cannot always provide sufficient warning for large numbers of people to escape to high ground, leaving them trapped with no escape. Therefore on site refuges are required, which in turn will not be feasible unless buildings are strengthened to withstand the forces of flooding, and which in turn is unlikely to be feasible unless works are undertaken to reduce the forces of flooding on buildings. Although some of the management measures of the Plan are aimed at marginally reducing floods it must be recognised that severe flash flooding will always be part of the Wallsend Commercial Centre.

The benefits and limitations of the measures proposed are summarised in the following table:

Category	Draft Measures	Risk to Life		Risk to Property		Concept Costs
		Can	Cannot	Can	Cannot	
Emergency Mgt / Flood Readiness	•Warning •Education •SES Plan	•Inform •Prepare	•Save many people •Stop flooding	•Inform •Prepare •Reduce losses	•Eliminate all losses •Stop flooding	To be defined by LEMC
Living with the Risk	•Refuges •Strengthen buildings * •Walkway	•Save people	•Stop flooding	•Protect Buildings	•Stop flooding •Protect Stock	$16M
Reducing the Risk	•Flow Path •Planning controls •Insurance	• *enable strengthening •Reduce exposure	•Stop flooding	•Reduce Exposure	•Stop flooding	$28M
						$44M +

Table 1 – Benefits and Limitations Summary of Plan elements

(Note: "LEMC" =Local Emergency Management Committee)

As indicated in Table 1 above, the concept cost of executing this plan is in the order of $44 million with additional costs for the emergency management of flood readiness components and ongoing annual expenditure to support emergency management.

The implementation of the Plan is beyond the financial resources of Council or most property owners and in excess of the customary budgeting constraints of the State and Federal Floodplain Management Grants Scheme. A special treasury allocation of funds would be needed to ensure the timely and efficient implementation of the plan.

The development and implementation of a Floodplain Risk Management Plan is a partnership. No single organisation, person or group of people has an entire responsibility for all management of flood risks. Instead, a coordinated, unified and partnered approach is required to successfully manage flood risks. We should therefore think of a whole of community "Partnership of Floodplain Management" consisting of affected and interested people, community groups and associations, Government agencies and Council working together.

The community - including business and the Wallsend Town Committee – were given opportunity for active involvement in the exhibition of the Draft Study and Plan. It is essential that the whole community be consulted and given opportunity for involvement in the implementation phases and this is recommended in the Plan.

In the event that the hazard reduction measures are not undertaken it is recommended that either:

- A sunset policy be applied to the affected area of the Commercial Centre (excluding any future development or re-development which would be required to be compatible with the flood risks)

  OR

- The Wallsend Commercial Centre be relocated to flood free land.

The next section of this Report - the "Floodplain Risk Management Plan for the Wallsend Commercial Centre" – gives more detail about the coordinated and interdependent measures summarised in this Synopsis.

Floodplain Risk Management Plan for the Wallsend Commercial Centre

Floodplain Risk Management Plan for the Wallsend Commercial Centre

1. INTRODUCTION

This Plan is an all of community plan which sets out prioritised works and actions designed to manage the extraordinary flood risks in the Wallsend Commercial Centre. It is the culmination of extensive research and community input.

This Plan applies principles and criteria that have been developed in accordance with the NSW Government Floodplain Development Manual across the Newcastle Local Government area by specialist consultants. These principles and criteria were reviewed in late 2008 by a panel of experts drawn from other Councils, Government Agencies and practitioners, who unanimously concluded managing the potential risks to life must be the utmost priority.

This Plan will be consistent with others Plans as they are progressively developed across the Newcastle Local Government Area in the next 18 months.

The next part of this document, the Floodplain Risk Management Study for the Wallsend Commercial Centre, provides background and full rationale for the recommendations in this Plan.

The Wallsend Commercial Centre has been given priority over other areas because it has the highest level of flood risk exposure in the Newcastle Local Government Area.

2. WHAT THE PLAN IS

This Floodplain Risk Management Plan for the Wallsend Commercial Centre sets out recommended works and actions to manage the full potential risks from flash flooding that, in summary, are aimed at:

- Reducing the danger to human safety as the utmost priority
- Reducing the danger to property, including critical infrastructure
- Ensuring future development is controlled and compatible with the flood risk and danger to personal safety
- Ensuring future development is controlled and compatible with the flood risk to material things.
- Providing information to improve emergency response management.
- Ensuring the support of the local community
- Ensuring the actions meet Ecological Sustainable Development principles, are socially sustainable, economically achievable, and maximise positive impacts while minimising negative impacts.
- Providing a program for implementation that includes funding mechanisms, priorities, staging, responsibilities, constraints and monitoring
- Presenting a coordinated mix of measures that address existing, continuing and future risks
- Requiring ongoing monitoring of the Plan after adoption by Council, recognising a management plan can never be truly finalised.

The Plan applies to flood prone land between Cowper Street and Federal Park Wallsend which is outlined in red in the figure below:

Figure 1 - Wallsend Commercial Centre

3. WHOLE OF COMMUNITY PARTNERSHIPS

The development and implementation of a Floodplain Risk Management Plan is a partnership. No single organisation, person or group of people has an entire responsibility for all management of flood risks. Instead, a coordinated, unified and partnered approach is required to successfully manage flood risks. We should therefore think of a "Partnership of Floodplain Management" consisting of affected and interested people, community groups and associations, Government agencies and Council working together.

The "Partnership of Floodplain Management" for the Wallsend Commercial Centre potentially includes:

- Owners of land in the commercial Centre (public and private)
- Owners / operators of buildings, businesses and assets in the Commercial Centre (public and private)
- Newcastle City Council (The management of flood prone land is, primarily, the responsibility of Councils. For example: Land use planning, flood data and hazard mapping, engagement of expert consultants to advise, convening Newcastle Floodplain Risk Management Committee.)
- Hunter Water (Ownership and maintenance of the major concrete lined stormwater Channel)
- NSW Government (Department of Environment and Climate Change for Policy support (the Floodplain Development Manual), financial assistance, technical assistance; Department of Planning for regional strategies and plans, approvals of major development and (s117) planning directives to Councils; and Catchment Management Authorities)
- Commonwealth Government (financial natural disaster relief, flood forecasting and warning through the Bureau of Meteorology, direct assistance for management measures where required for national security. Also through the Commonwealth Office for Emergency Services to coordinate natural disaster mitigation funding.)
- State Emergency Service (combat agency to lead the development and maintenance of local flood (emergency) plans for response to and initial recovery from floods, flood emergency response education).
- Local Emergency Management Committee
- Department of Community Services (welfare relief in the aftermath of a flood)
- Developers
- Insurers

Community involvement is essential. It cannot be stressed too strongly that community involvement in all phases of the floodplain risk management process is essential to the development, acceptance and implementation of effective management plans.

The community - including business and the Wallsend Town Committee – were given opportunity for active involvement in the exhibition of the Draft Study and Plan. Representatives from the Wallsend Town Committee attended the Newcastle Floodplain Risk Management Committee (FRMC) meeting on 27 November 2008 to meet with the consultant to present their ideas and concerns and attended the FRMC meeting on 5 February 2009 to discuss with the consultant his preliminary findings. Briefings on the draft Study and Plan were delivered to the Wallsend Town Centre Committee on 1 April 2009 a breakfast event for owners and businesses in the Commercial Centre on 6 May 2009.

It is essential that the whole community be consulted and given opportunity for involvement in the implementation phases and this is recommended.

It can't be stressed too strongly that both the development and implementation of Floodplain Risk Management Plan is a partnership between the community, Council and Government.

Community involvement to date – including the exhibition of the Draft Study and Plan from 11 April to 10 June 2009 - is documented in the Study (See Section 6).

4. KEY BACKGROUND

The Wallsend Commercial Centre presents a significant floodplain constriction between Wallsend Park and Federal Park, where the creek is confined to a narrow concrete lined channel. On both sides of the channel, commercial buildings act as a barrier to overbank flood flows. In effect, the shops and other commercial buildings act like a dam causing large floods to build up a 'head' of water upstream of Nelson St to push the flow through. This build up creates the energy to force floodwater along the streets and through the carparks of the business district i.e. the streets are default flood paths. In large floods the flow through the streets and carparks can be fast moving with strong and dangerous currents.

During the 1988 and 1990 floods, which have been estimated to be about 1 in 10 to 1 in 15 annual chance floods *(DHI 2008)*, the backup in water level behind the shops in Nelson St was measured as 0.5m. The June 2007 flood is estimated as a 1 in 40 to a 1 in 100 annual chance flood through the commercial district (*DHI 2008*) where depths reached 1.5m in the area behind the shops along Nelson Street. Modelling shows this figure can well exceed 1.5 metres in very large floods.

The Draft Study and Plan were publicly exhibited from 11 April to 10 June 2009. The Community – including business and the Wallsend Town Committee – were given active involvement in the exhibition of the Draft Study and Plan. It is essential that the whole community be consulted and given opportunity for involvement in the detail implementation phases.

4.1 Location and Catchment

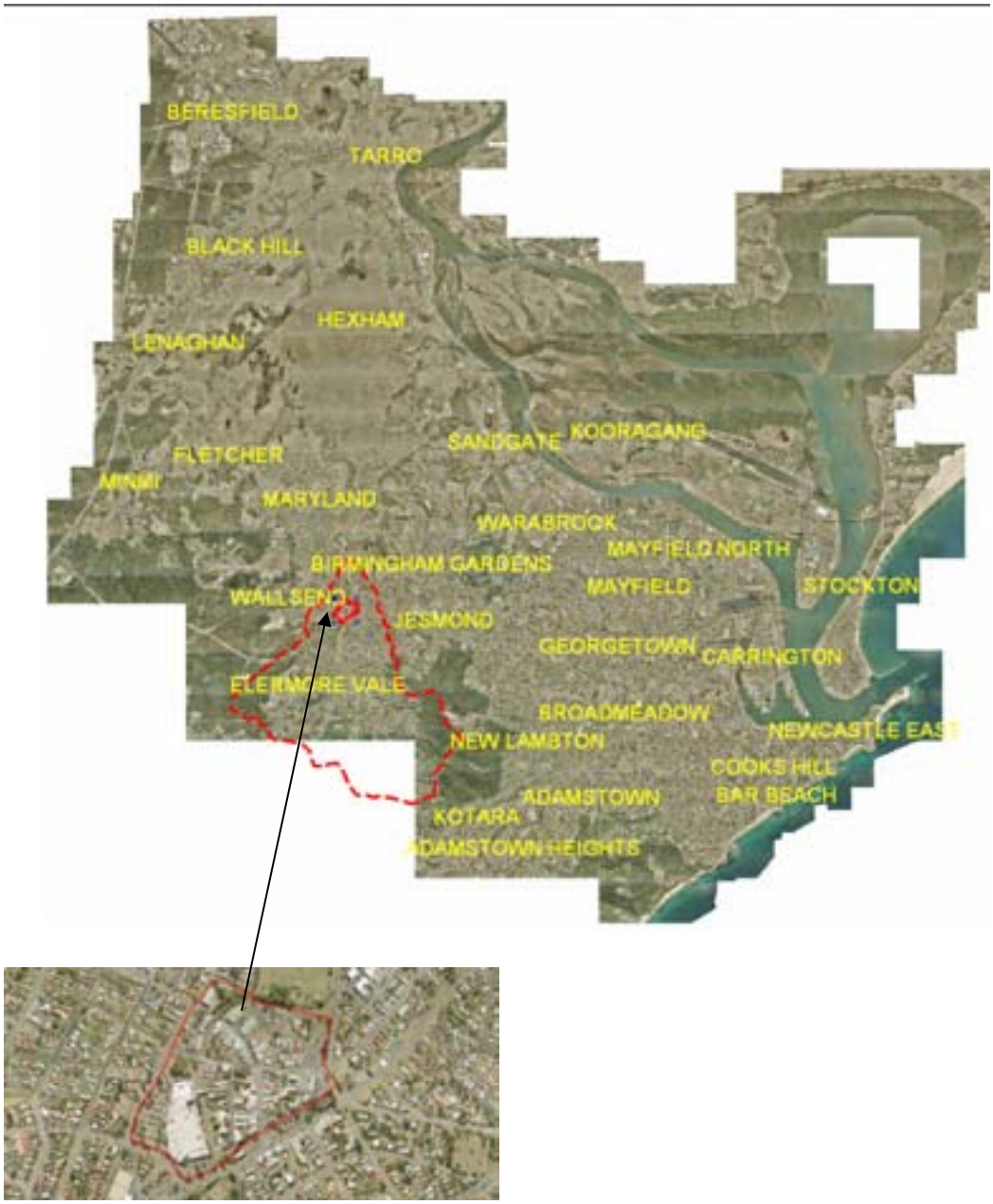


Figure 2 – Ironbark Creek Catchment Location

4.2 Flood Environment

While the probable maximum flood is extremely rare it is an indicator of the ultimate affect that a flood can have on a community. In the Wallsend Catchment flash floods can occur with no effective warning since presently available flood warning systems cannot be solely relied on to save people since it is not fail safe and since it cannot always provide sufficient warning for large numbers of people to escape to high ground, leaving them trapped with no escape. The larger floods can rapidly envelop buildings with deep and swiftly flowing water which is too dangerous for self-directed evacuation by wading. People can be trapped in buildings with the enclosing floodwater rapidly increasing in energy to the point where the buildings can sustain extensive structural damage. Many buildings could collapse, drowning those trapped in them. The rapid escalation of the energy of the enclosing waters means that it would be extremely dangerous for rescue attempts.

The following map (Figure 3) shows the worst conceivable flash flood in the Wallsend Commercial Centre and surrounds. The areas shown as “H5” rise to several metres deep in less than half an hour with little or no warning. The Study provides similar maps for other floods, and gives a full description of the likely consequences.

Note: Some of the Wallsend Commercial Centre site can be affected by Hunter River Flooding. Flooding from the Hunter River rises and falls very slowly, with warning expected in days. Since this does not pose an extreme risk to life, potential risks from Hunter River flooding in the Wallsend Commercial Centre will be considered as part of the development of a Floodplain Risk Management Plan for the entire Newcastle local government area which is being developed over the next eighteen months. The Plan for the entire local government area will then incorporate this Plan for the Wallsend Commercial Centre and – after review – the previous Draft Wallsend Plattsburg Floodplain Risk Management Study and Plan (March 2007). For more information see Section 2.9 of the Study.

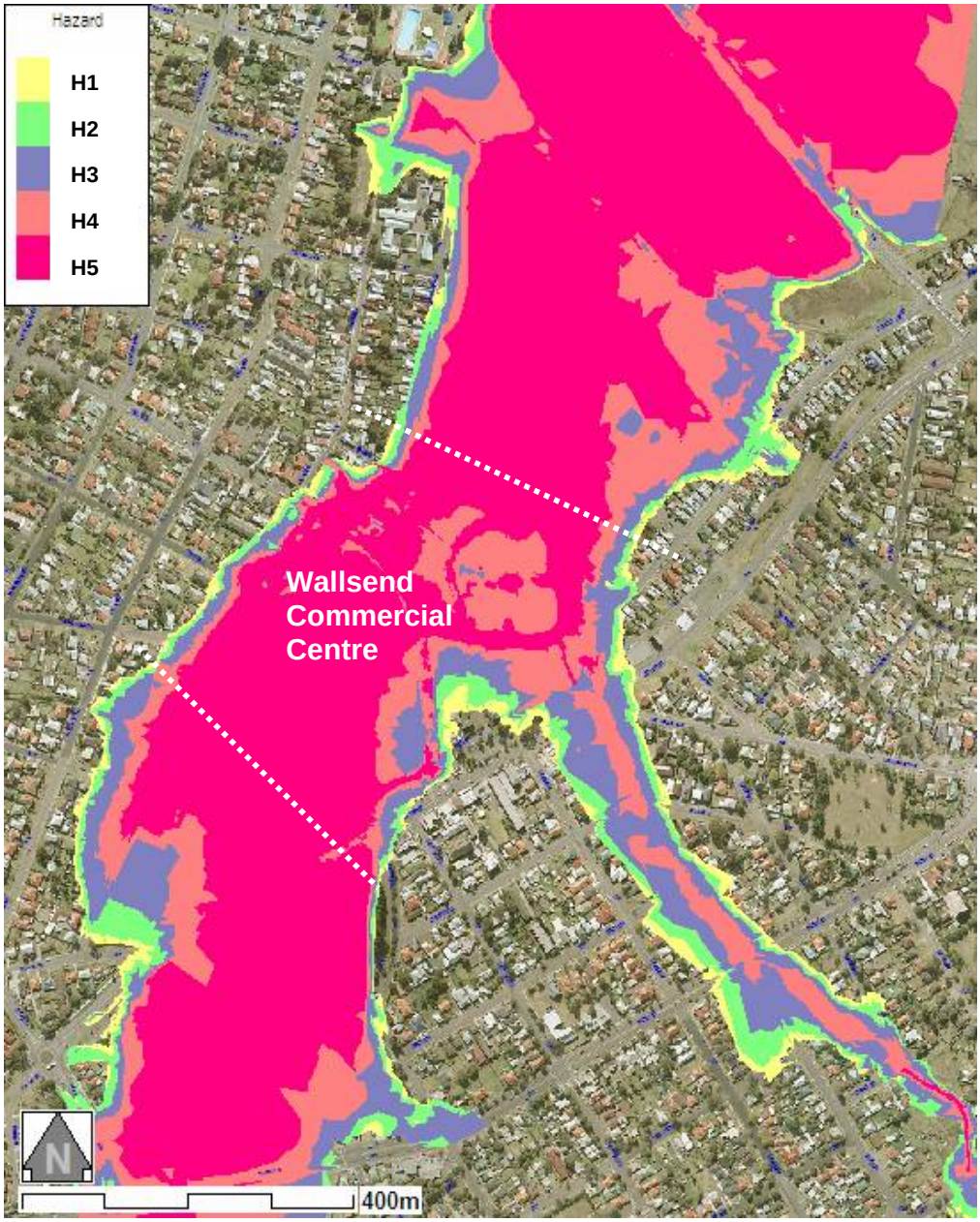


Figure 3 - Commercial Centre Peak Hazards - Probable Maximum Flood

4.3 Potential Options considered

Potential options for consideration originated from:

- The NSW Government Floodplain Development Manual – the management of flood liable land (2005)
- The Draft Wallsend Floodplain Risk Management Study and Plan (March 2007). Eighteen options (refer the Study Appendix C) were canvassed through public meetings and an exhibition in preparation of this draft Plan. *(It is appropriate to note that unfortunately it was found at the time not all options could be tested because the computer flood modelling software that had been used for many years in the Wallsend catchment could not manage the complexity of some of these options. Therefore the Draft Study for the entire Wallsend catchment was not able to be completed at the time.)*
- Community feedback, both in response to community consultation undertaken in late 2006 as part of the above study (refer Section 6.2) and in phone calls and correspondence received by Council after the 8 June 2007 flood event.
- Discussions with Government
- Members of the Newcastle Floodplain Risk Management Committee
- A survey of all identifiable floodplain risk management options (including a world wide literature search) carried out as part of a separate City Wide Flood Planning Study (Stage 1) commissioned in 2008.
- An experts' panel workshop convened in October 2008 with experts drawn of other Councils, Government and practitioners.

The computer flood model was updated to the latest software to enable all options to be scenario tested as considered necessary. Options which previously could not be scenario tested with the old model were able to be simulated and tested in the new updated model. This was a complex process that included identifying and measuring heights of more than a hundred observed flood levels in the Wallsend area from the 8 June 2007 flood event, ensuring the new model reproduced what was observed in that flood.

Each potential option has now been scenario tested with the new computer flood model, where relevant, and considered in terms of its ability to contribute to a positive flood risk management outcome, advantages, disadvantages, and cost.

It is important to appreciate many options require other options to be carried out, and therefore are not options in isolation. For example, creating refuges above the highest flood requires buildings containing these refuges to be strengthened so they are not swept away from the force of enclosing floodwaters, and it turn it would not be feasible to strengthen many buildings unless works were undertaken to reduce the flood forces on those buildings.

Potential options have been grouped together according to:

- **Emergency Management and Flood Readiness** *(Local Emergency Management Committee / Emergency Agencies)*
- **Living with the Risk** *(Private Land Holders on Private Land)* AND
- **Reducing the Risk** *(Government works on Public Land and Planning Controls)*

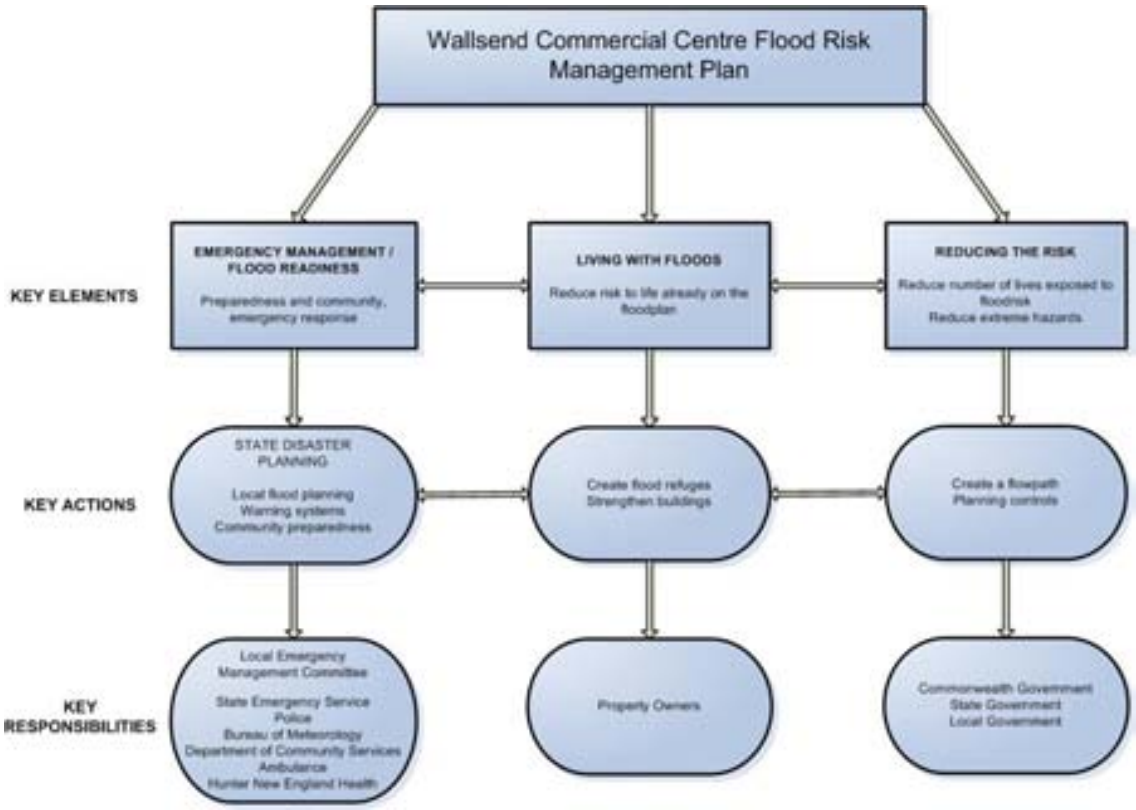
Each option has been considered in the Study in terms of its ability to contribute a positive flood risk management outcome, advantages and disadvantages and cost. The following are examples of the options that have been taken into account but found either ineffective, or the disadvantages outweighed any benefits:

- Construct Detention Basins
- Velocity Deflector Walls
- Extend Concrete lining of Channel to Minmi Road
- Relocation of Wallsend Commercial Centre
- Remove Wallsend Plaza
- Rainwater tanks and distributed detention
- Widening the major Stormwater Channel and providing training walls to stop flooding

More information can be found in Section 7 of the Study in the discussion of individual potential options.

5. RECOMMENDED WORKS AND ACTIONS

The following flow chart identifies the key elements for managing flood risk in the Wallsend Commercial Centre.



Each of these three key elements – **Emergency Management and Flood Readiness**; **Living with Floods** and **Reducing the Risk** - need to come together to reduce the flood risk in the Wallsend Commercial Centre. For example, a flash flood warning system cannot be solely relied on to save people since it is not fail safe and since it cannot always provide sufficient warning for large numbers of people to escape to high ground, leaving them trapped with no escape. Therefore on site refuges are required, which in turn will not be feasible unless buildings are strengthened to withstand the forces of flooding, and which in turn is unlikely to be feasible unless works are undertaken to reduce the forces of flooding on buildings. Although some of the management measures of the Plan are aimed at marginally reducing floods it must be recognised that severe flash flooding will always be part of the Wallsend Commercial Centre.

5.1 Emergency Management/Flood Readiness

Emergency management in a flood risk environment such as the one in the Wallsend Commercial Centre will be one of the key responses to managing risk to life.

The Local Emergency Management Committee coordinated by the NSW Police and with representatives of the SES, local government etc have the overall responsibility for ongoing management.

The Newcastle Local Disaster Plan (DISPLAN) details arrangements for the response to emergencies. The Plan sets out the roles and responsibilities of agencies such as the NSW Police, SES and Fire Brigade. The Newcastle CBD has an Emergency Arrangements Annex as an annexure to the Newcastle DISPLAN (http://www.newcastle.nsw.gov.au/__data/assets/pdf_file/0006/33747/Newcastle_CBD_Emergency_Arrangements_Public_2008.pdf). See also http://www.emergencynewcastle.com.au/ for "Ready 123 in an emergency" (which present applies to the Newcastle Central Business District).

It is recommended that community groups (such as the Wallsend Emergency Network) work 'hand in hand' with the Local Emergency Management Committee.

5.1.1 Emergency Management and Flood Warning System

An emergency management and flood warning system must be developed and managed as a whole. A failure of one element can lead to complete failure. Although weather / environmental detection equipment and alarms are key elements, a complete flood warning system comprises:

- Data collection and transmission equipment
- Communication equipment (public and private) / protocols
- "Trigger" criteria
- Response to the "trigger" such as:
  - Monitor closely, OR
  - Issue advice such as:
    - Watch and wait for further advice, OR
    - Prepare (eg make sure refuges are accessible) OR
    - Act (eg stay away from car parks and go to upper storey refuges).
- Predetermined, documented likely necessary evasive actions for a range of possible floods (up to the PMF) including definition of roles/responsibilities in addition to the ability to adapt and make decisions "on the fly".
- People who direct others (where and if needed)
- The affected community who need to respond (who therefore need to be aware and educated how to respond before the event)
- Maintenance (equipment, organisation and awareness)
- Performance review / improvement where available and warranted.

At the time of writing, Newcastle City Council had let a contract for the supply and installation of ten rainfall measurement stations across the Newcastle Local Government Area *(one at the site of the Wallsend Bowls Club)* and two water level measuring stations *(one on the creek at Croudace Road Elermore Vale)*. When installed (expected by the end of April 2009) these measurement stations will provide information to the Bureau of Meteorology who in turn provide warnings to the emergency service such as the SES and police, as well as the media who broadcast to the community.

With present technology and the detection equipment installed, the Bureau of Meteorology have advised it is unlikely that warning cannot always be provided sufficiently in advance of a catastrophic flash flood to enable the large numbers of people who could be present in the Wallsend Commercial Centre to evacuate to higher flood free ground. A warning system alone would certainly not be fail safe. Therefore the capacity for evacuation to upper storey refuges in buildings capable of withstanding the forces imposed by a catastrophic flash flood will be required. At present it is estimated that no buildings in the main flow areas (*i.e. most of the buildings in the Wallsend Commercial Centre including Wallsend Plaza*) would be capable of withstanding such forces.

For the immediate future, until works can be achieved to reduce flood forces on buildings and upper storey refuges are created within buildings capable of remaining stable, a Flash Flood Warning System will probably not be able to safely evacuate large numbers of people, and many would still perish if an extreme event were to occur.

This issue needs to be further considered by the Local Emergency Management Committee.

5.1.2 Complete Flood Emergency Planning

Community awareness and preparedness about what actions should be taken when caught in a flash flood is vital to reducing the risk to life. If an extreme flash flood occurred tomorrow, many people could die because they do not know what to do.

A comprehensive program of community education and training needs to be set up and implemented. The program would need to consider issues such as:

- Flood depth indicators and flood warning signs;
- Special flash flood warning signs in carparks;
- Possible flash flood early warning methods such as sirens;
- Selection of flood wardens in commercial centre and a regular program of response training;
- Education on purpose and proper use of flood refuges;
- Preparation of individual site Flash Flood Response Plans throughout the Commercial Centre;
- Regular communications re: printed handouts, media broadcast and others;
- Special requirements for large or difficult sites eg. the Plaza.

Since flash flooding can occur simultaneously over large parts of the Newcastle Local Government Area (as evidenced by the 8 June 2007 storm event) which would require a city wide response, it is recommended the completion of flood emergency response planning be carried out by the Local

Emergency Management Committee to produce a Newcastle Local Government Area Wide "Local Flood Plan" integrated with the Local Disaster Plan (DISPLAN). This would build on the work already undertaken in the Newcastle CBD (see earlier under s5.1). Such emergency planning would draw on the expertise of the various emergency management organisations such as the SES. Council has supplied the SES with flash flood hazard mapping across the whole of the Newcastle LGA to assist in this planning.

The SES produces locally customised Floodsafe Guides for flood-prone communities or specific flood risk areas. In addition the SES conducts media campaigns and works with Councils to run public activities to increase awareness. The main objectives (in general) are:

- Familiarising communities with the flood threat or reminding them about it
- Informing people about the arrangements which have been made for managing it, and
- Indicating to them how they can help protect themselves and properties from the effects of flooding.

For the immediate future, it appears the scope for the "Local Flood Plan" to provide for flash flooding in the Wallsend Commercial Centre would be severely limited. This is because, as described in the above section, until works can be achieved to reduce flood forces on buildings, and upper storey refuges are created within buildings capable of remaining stable, a Flash Flood Warning System will probably not be able to safely evacuate large numbers of people, and many would still perish.

Even with the provision of refuges, it would still be important for emergency planning and education to take into account the potential risks to people who may find themselves trapped in vehicles – perhaps by attempting to escape – and people with mobility limitations who may have difficulty gaining access to refuges. Past history in the Wallsend Commercial Centre provides examples of the rapid rise of flash flooding and vehicles being swept away.

It is recommended that the SES reference this Wallsend Commercial Centre Floodplain Risk Management Plan when they prepare their "Local Flood Plan" to include the Wallsend Commercial Centre.

5.2 Living with Floods

This category of works and actions applies to private land, where as part of a "whole of community", costs of implementation are proposed to the borne by owners (/ occupiers). In regard to businesses, the **Occupational Health and Safety Regulation 2001** states an employer must have arrangements in place in the event of emergencies. (Visit http://www.austlii.edu.au/au/legis/nsw/consol_reg/ohasr2001364/index.html or http://www.workcover.nsw.gov.au/Pages/default.aspx .)

5.2.1 Create flood refuges

Industrial and commercial buildings in the Wallsend Commercial Centre that are in the floodway should have either a second storey or mezzanine floor as a flood refuge. The flood refuge in Council's newly constructed public library is a good example.

Assuming that two storey buildings have adequate provision for a flood refuge, Council's property database indicates that approximately 58 buildings require refuges.

In addition, for the Wallsend Plaza Shopping Centre the Preferred Solution is to remove people and their cars from the path of flash floods across the Plaza site by major site rebuilding involving a multi-storey carpark and shopping areas all located above the PMF. The existing carpark would become a dedicated floodway with no parking allowed. However, as the initiative, timing and funding of the Preferred Solution would rest with the owner entirely, this possibility cannot be relied upon and given any time horizon in this Management Plan. Therefore, as the Plaza Shopping Centre, and particularly its carpark, afford the greatest potential for loss of life in the Commercial Centre interim measures are required to manage the risk to life:

- An elevated walkway within the Plaza and carpark with multiple internal and carpark feeders would help people stranded in the Shopping Centre and trapped in cars in the car park to get to safety. The walkway would need to be of heavy steel construction to withstand the hydraulic loads of large floods *(with debris loading due to floating cars)* and be wide enough to allow rapid transfer of people to land above the PMF.
- It may be possible to link the walkway to the Plaza second storey offices to create a refuge for elderly or injured persons, subject to suitable structural strengthening of the building.

A refuge would be of little value if the building would be likely to suffer substantial structural damage or fail in a severe flood. Hence a co-requisite of the creation of refuges is the structural strengthening of the building so that it can safely withstand the applied hydraulic loads of a severe flood. As this applies to all buildings in the Commercial Centre, not just the single storey buildings, structural strengthening is discussed separately below.

As previously pointed out, buildings in the Wallsend Commercial Centre could suffer substantial structural damage which could endanger lives. Hence the creation of refuges should not be delayed. It is considered that all refuges should be constructed over a period of 5 to 10 years

Buildings in Council, Tyrrell, Nelson and Boscawen Streets are the most vulnerable, even in lesser floods and it should be a prerequisite that the buildings are strengthened either at the same time or prior to refuges being built.

The cost of constructing approximately 58 flood refuges is estimated to be in the order of $5.4 million (excluding the Wallsend Plaza Shopping Centre). For the Wallsend Plaza Shopping Centre, the cost of providing an elevated walkway, 3m wide, with multiple internal and carpark feeders is estimated to cost $3 million. Notwithstanding the above, the strengthening of buildings and provision of flood refuges will only be effective if the flood risk is also reduced.

5.3 Reducing the Risk

5.3.1 Create Flow Path

To reduce the force of flash flood waters in extreme events (where the risk to life is greatest) from present conditions where most buildings (including Wallsend Plaza Shopping Centre) would be in danger of collapse, to a lesser force which would enable practical strengthening of buildings as a pre-requisite to providing upper storey refuges.

There are two main components:

- Increasing the flow capacity under Minmi Road, and
- Removing buildings and some bridges, and widening the channel between the downstream end of the Wallsend Plaza Shopping Centre and Federal Park.

Description of Works to increase flow capacity under Minmi Rd

In order to be effective, the flowpath leading to, and beneath, Minmi Road must have a sufficiently large cross-sectional area in order to convey flows during an extreme flood event. By minimising the restriction at this point, floodwaters in the Wallsend Commercial Centre will be “allowed” to drain more efficiently, leading to lower flood levels and a hazard reduction across the downstream portion of the Commercial Centre.

To achieve this, an average channel width of 55 m was chosen, beginning at the north side of Federal Park, continuing approximately 75 m north past Minmi Road into the low area of Hexham Swamp. In order to successfully funnel flows from Federal Park into the channel (and therefore beneath Minmi Road) an entrance width of approximately 75 m was selected. At the outlet, the channel expands to a width of approximately 80 m, with an apron across Hexham Swamp excavated gradually to merge the channel with the adjacent terrain.

Details of the proposal are as follows:

Excavation	The channel is proposed to have a trapezoidal cross-section, maintaining the lower portions of Ironbark Creek. The channel’s base would be excavated to an elevation of 1 m AHD at the Federal Park entrance and graded to an elevation of 0.4 m AHD at the downstream end. The sides of the channel would have slopes of 1 in 3 to merge with the existing terrain. The majority of the channel would be grass covered, with the original portions of Ironbark Creek to be lined in concrete.
Bridge Construction	The bridge at Minmi Street would require an extension or total redevelopment in order to cross the larger channel. It is important that the Minmi Street bridge does not undermine the objective of the project by restricting flow in the channel. Costs given in this report have been estimated based on complete demolition of the existing bridge and replacement with new larger Deck/Girder style bridge.

The total cost of developing the downstream flow channel is estimated to be in the order of $5.4million with the most significant element being the new bridge.

Figure 4 shows the proposed layout of the Downstream Channel Flow Path.

Figure 4 - Downstream Channel Schematic Configuration

Description of "Short Channel Flow Path"

In order to be effective, the flow path through the Wallsend Commercial Centre must have a sufficiently large cross-sectional area in order to convey significant flows during an extreme flood event. Additionally, flows through the Shopping Plaza car park which conveys half of the peak discharge of the PMF will need to be efficiently fed into this wider channel.

To achieve this, an average channel width of 45 m was chosen based on a maximised feasible Commercial Centre layout, beginning at the north side of the Shopping Plaza car park and continuing to the Federal Park side of the Boscawen St Bridge along Ironbark Creek. In order to successfully direct all flows from the car park into the channel, an initial channel width of approximately 90m was selected.

Details of the proposal are as follows:

Acquisition and Demolition	At least eight industrial, commercial and residential properties are required to be demolished in order to create the channel through the Commercial Centre. Bridges at Tyrrell and Boscawen Streets would be required to be demolished.
Excavation	The channel is proposed to have a 'U-shaped' cross-section in order to maximise its potential flow conveyance. The channel's base would be excavated to a height of 1.75 m AHD at the Shopping Centre Car Park entrance and graded to a height of 1.25 m AHD at the Federal Park side exit to the channel. The channel would be concrete-lined.
Bridge Construction	The bridge at Nelson Street would require an extension or total redevelopment in order to not only cover the now larger channel, but also in order to convey the increase traffic volume as a result of the closure of the Tyrell and Boscawen Street Bridges. Costs given in this report have been estimated based on complete demolition of the existing culvert style bridge and replacement with new larger Deck/Girder style bridge.
Tyrrell Street Works	An area no greater than 200 m^2 of Tyrrell Street, adjacent to Nelson Street, would be raised as a pseudo-levee, in order to increase the time for evacuation along Nelson Street.

Figure 5 shows the proposed layout of the Commercial Centre Short Channel Flow Path.

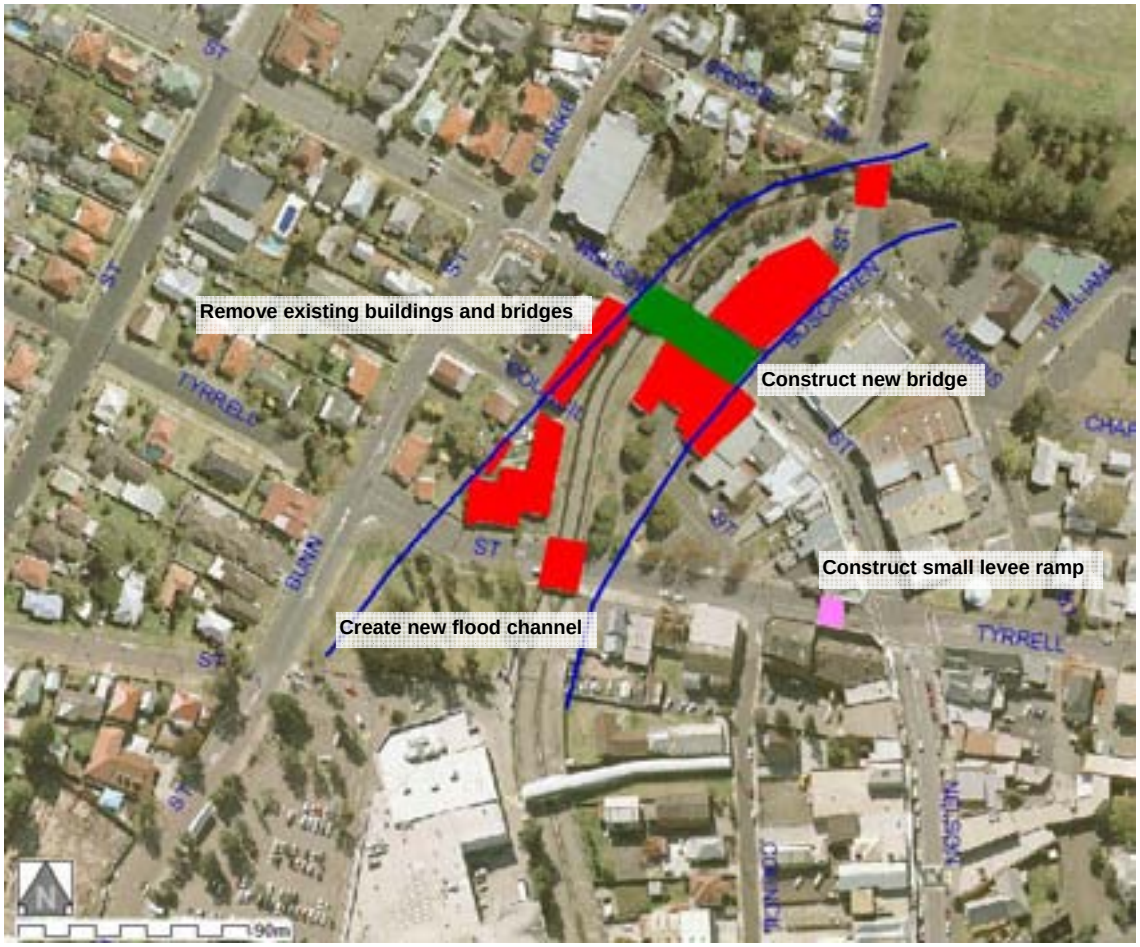


Figure 5 – Wallsend Commercial Centre Short Channel Flow Path

The total cost of developing the short flow channel is in the order of $15.4million with property acquisition costs.

5.3.2 Define Floodway, Flood Storage and Flood Fringe

Floodway, Flood Storage and Flood Fringe areas are required to ensure the cumulative impacts of future developments in the floodplain do not increase the potential risk to life and property. A map which defines the floodplain of Ironbark Creek through the Wallsend Commercial Centre has been developed and is reproduced below:

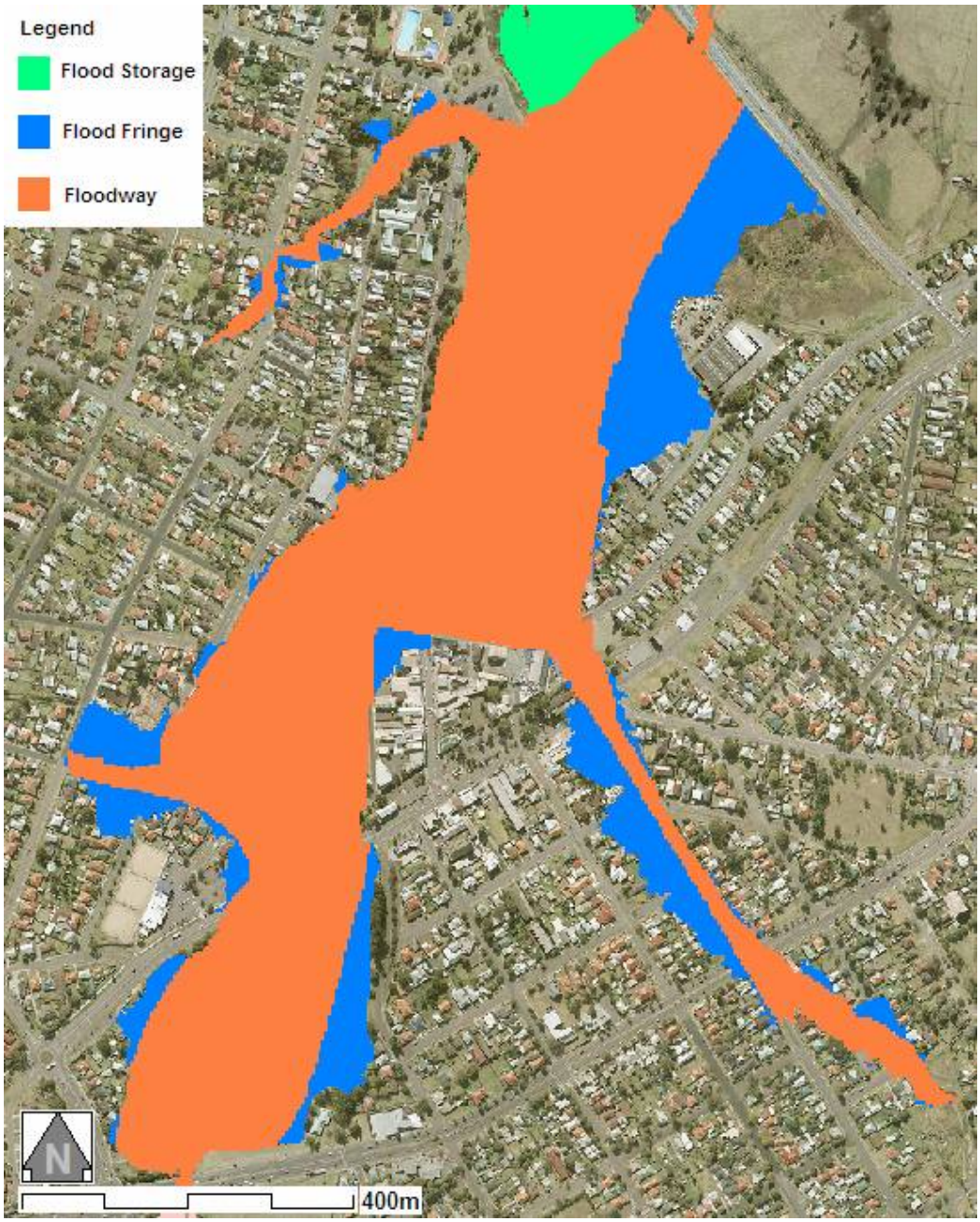


Figure 6 – Commercial Centre Hydraulic Categories

The categories are based on existing conditions. Developments proposing additional footprints beyond existing development in Floodway areas would (in general) not be permitted. Developments proposing additional footprints in Flood Storage areas would (in general) be subject to limitations in

accordance with the planning controls of the day. Developments proposing additional footprints in Flood Fringe areas would, in general, not be subject to any restrictions relating the extent of the development.

For more information refer to Section 7.3.9 of the Study.

5.3.3 Amend Newcastle Development Control Plan 2005

Newcastle City Council has a number of land use planning policy documents which manage and direct the sustainable growth of Newcastle and its surrounds. Some elements of these documents are not considered to be wholly consistent with the measures and procedures necessary to support the management of risk to life and property during an extreme flash flood. Accordingly, these documents should be amended during Council's current review of its planning documents.

6. IMPLEMENTATION

Any floodplain risk management plan is unlikely to be implemented immediately in its entirety. For example, availability of funds will determine when mitigation works can commence. Hence the implementation of the plan needs to be staged in accordance with priorities established from consideration of, inter alia:

- How soon they can be implemented;
- Resourcing required;
- The constraints that exist (including financial and physical);
- How these can be addressed; and
- How effective the measures are.

6.1 Funding Overview

The concept cost of executing this plan is in the order of $44 million with additional costs for the emergency management of flood readiness components and ongoing annual expenditure to support emergency management. (See Table 6.3.1)

The implementation of the Plan is beyond the financial resources of Council and most property owners and in excess of the customary budgeting constraints of the State and Federal Floodplain Management Grants Scheme. A special treasury allocation of funds would be needed to ensure the timely and efficient implementation of the plan.

There is a precedent for such an allocation in the Hawkesbury-Nepean Floodplain Management Project. This project involved a special allocation from Treasury for the construction of extensive flood evacuation infrastructure *(i.e. road upgrades, new bridge)* as well as early flood warning, flood awareness and preparedness measures as well as flood compatible development guidelines. The driving force behind the Hawkesbury-Nepean project was the risk to life facing a large number of residents in the Hawkesbury-Nepean valley in the event of an extreme flood.

6.2 Need for a Wallsend Commercial Centre Task Force

The scale and technical complexity of the flood risk management measures outlined in the Study are beyond the technical and project management skills of local government. Their implementation will involve structural retrofitting of building as well as civil engineering works within the active environment of a busy business, shopping and industrial district.

High level project management experience will be needed to negotiate approvals with the many building owners and/or lessees involved as well as the general public. This project management experience will also need to embrace difficult contract tendering and contract administration within a dynamic building environment.

The implementation of a myriad of complex design and construction and project management issues within a built up environment and active business district is akin to the rebuilding of Hamilton after the 1989 earthquake. It is considered that the implementation of the Wallsend Flood Risk Management Plan will require a Task Force similar to that set up for Hamilton.

Implementation of the Plan is complicated because of the interrelated nature of the various flood risk management measures. They need to be implemented simultaneously in the Commercial Centre, and managed holistically otherwise implementation would become fragmented and inefficient which would comprise both time and cost control. Inefficient project control would also prolong disruption to the day to day business activities of the Commercial Centre.

It is recommended that a special Task Force be established to implement the Wallsend Commercial Centre Flood Risk Management Plan.

6.3 Implementation Requires the Whole "Package".

Each of the three key elements – Emergency Management and Flood Readiness; Living with Floods and Reducing the Risk - need to come together as a single "Package" to reduce the flood risk in the Wallsend Commercial Centre. For example, a flash flood warning system cannot be solely relied on to save people since it is not fail safe and since it cannot always provide sufficient warning for large numbers of people to escape to high ground, leaving them trapped with no escape. Therefore on site refuges are required, which in turn will not be feasible unless buildings are strengthened to withstand the forces of flooding, and which in turn is unlikely to be feasible unless works are undertaken to reduce the forces of flooding on buildings. Although some of the management measures of the Plan are aimed at marginally reducing floods it must be recognised that severe flash flooding will always be part of the Wallsend Commercial Centre.

The benefits and limitations of the measures proposed are summarised in the following table:

Category	Draft Measures	Risk to Life		Risk to Property		Concept Costs
		Can	Cannot	Can	Cannot	
Emergency Mgt / Flood Readiness	•Warning •Education •SES Plan	•Inform •Prepare	•Save many people •Stop flooding	•Inform •Prepare •Reduce losses	•Eliminate all losses •Stop flooding	To be defined by LEMC
Living with the Risk	•Refuges •Strengthen buildings * •Walkway	•Save people	•Stop flooding	•Protect Buildings	•Stop flooding •Protect Stock	$16M
Reducing the Risk	•Flow Path •Planning controls •Insurance	• *enable strengthening •Reduce exposure	•Stop flooding	•Reduce Exposure	•Stop flooding	$28M
						$44M +

Table 6.3.1 – Benefits and Limitations Summary of Plan Elements

(Note: "LEMC" =Local Emergency Management Committee)

The development and implementation of a Floodplain Risk Management Plan is a partnership. No single organisation, person or group of people has an entire responsibility for all management of flood risks. Instead, a coordinated, unified and partnered approach is required to successfully manage flood risks. We should therefore think of a whole of community "Partnership of Floodplain Management" consisting of affected and interested people, community groups and associations, Government agencies and Council working together. The community - including business and the Wallsend Town Committee – were given opportunity for active involvement in the exhibition of the Draft Study and Plan. Similarly, it is essential that the whole community be consulted and given opportunity for involvement in the implementation phases.

It is proposed that Emergency Management and Flood Readiness implementation would be resourced and funded from emergency management agencies (such as the SES and Bureau of Meteorology), that "Living with Floods" measures" (on private land) implementation would be funded by the property owners, and that implementation of "Reducing the Risk" measures would be funded by Government, all coordinated through an implementation Task Force.

6.4 Implementation Timeline

Each of the three elements - Emergency Management and Flood Readiness; Living with Floods and Reducing the Risk – are interdependent and need to come together in the right sequence to reduce the flood risk in the Wallsend Commercial Centre. For example, a flash flood warning system cannot be solely relied on to save people since it is not fail safe and since it cannot always provide sufficient warning for large numbers of people to escape to high ground, leaving them trapped with no escape. Therefore on site refuges are required, which in turn will not be feasible unless buildings are strengthened to withstand the forces of flooding, and which in turn is unlikely to be feasible unless works are undertaken to reduce the forces of flooding on buildings. These relationships require implementation in the sequence shown in the following chart:

6.5 Review of this Plan

The NSW Government Floodplain Development Manual points out that a Floodplain is never truly finished, and therefore any adopted Plan should be periodically reviewed. The Manual suggests Plan should be reviewed at least every five years, or after a major flood event.

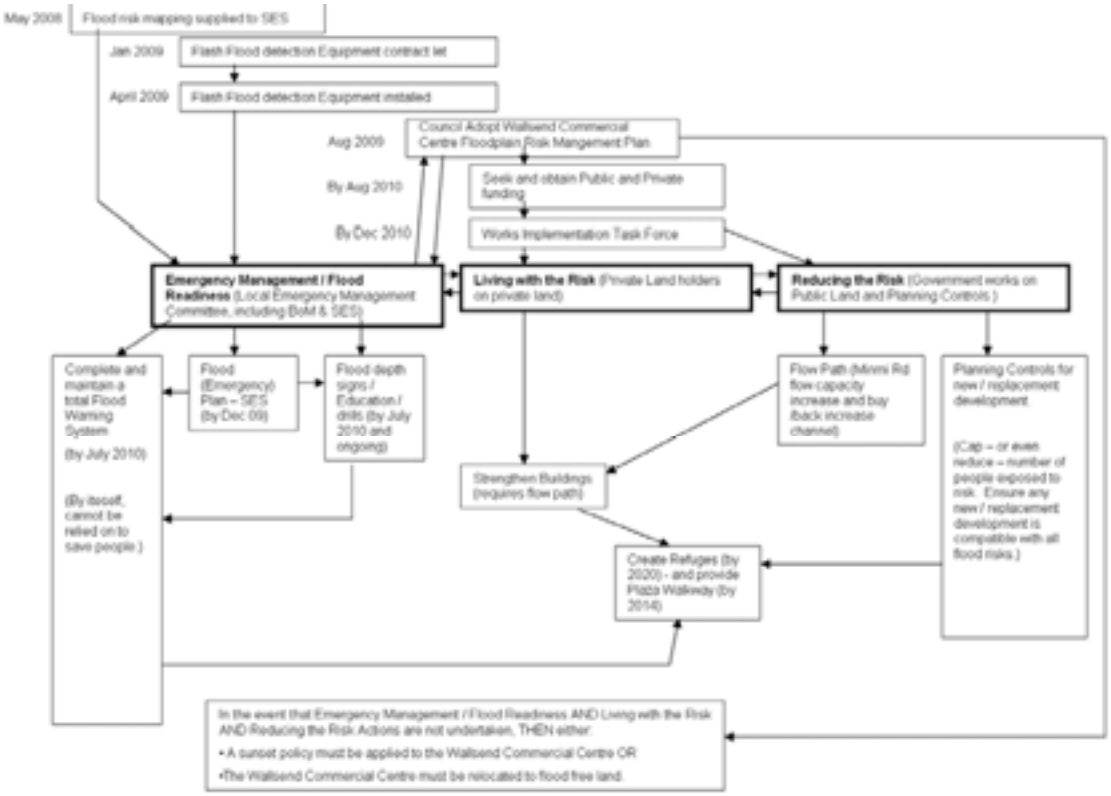


Figure 7 – Implementation Flowchart

Timing has been based on the recommendation of the Study (s7.2.1) that "As it goes toward reducing the risk to life, the creation of flood refuges in the Wallsend Commercial Centre should have a high priority. ... The creation of refuges and strengthening of buildings should not be delayed. It is considered that all refuges should be constructed over a period of 5 to 10 years". The longer time period has been taken to give maximum opportunity to construct the refuges within this recommendation.

The detailed design of any works dependent on quantifying flood flows and forces should be carried out using a further more finely detailed and refined computer flood model to ensure all impacts and design forces are properly taken into account.

In the event that the hazard reduction measures are not undertaken it is recommended that either:

- A sunset policy be applied to the affected area of the Commercial Centre (excluding any future development or re-development which would be required to be compatible with the flood risks)

  OR

- The Wallsend Commercial Centre be relocated to flood free land.

7. CONCLUSIONS

The Wallsend catchment is subject to flash floods which allow very little time for mobilisation and assistance by external emergency management resources. The safety of people will rely entirely on the cognisance of individuals.

On a busy day, in the Commercial Centre, thousands of lives could be at risk in the event of an extreme flash flood. The safety of these individuals will depend upon people seeking onsite refuge which is safe and secure, or on heeding and acting immediately on warnings.

The community must be informed of the hazards and associated risks individuals may be exposed to, including informing them about what action to take in an emergency. Given there are so many lives at risk, it is imperative that this is a priority.

The implementation of an emergency management 'Flood Plan' and the creation of safe refuges are required as a matter of urgency. If this is not done, the public will not be prepared for an extreme flash flood and many could die needlessly

However community awareness and refuges alone will not be sufficient. The hazard of the flood needs to be reduced by improving flood flow through Wallsend Commercial Centre necessitating significant capital works and localised property. Even with these works in place property owners in the floodway will still need to strengthen their buildings to avoid significant damage and the possibility of collapse.

The Wallsend Commercial Centre Flood Risk Management Plan devised by this study, requires public and private expenditure in the order of $44+ million for its implementation with an ongoing annual expenditure to support emergency management.

In the context of the risk to life, the Wallsend Commercial Centre community and Government agencies need to pursue the preferred high priority measures of the Plan as a matter of urgency.

The implementation of the Plan is beyond the financial resources of Council and in excess of the customary budgeting constraints of the State and Federal Floodplain Management Grants Scheme. A special treasury allocation of funds would be needed to ensure the timely and efficient implementation of the plan.

The development and implementation of a Floodplain Risk Management Plan is a partnership. No single organisation, person or group of people has an entire responsibility for all management of flood risks. Instead, a coordinated, unified and partnered approach is required to successfully manage flood risks. We should therefore think of a whole of community "Partnership of Floodplain Management" consisting of affected and interested people, community groups and associations, Government agencies and Council working together.

It is essential that the whole community be consulted and given opportunity for involvement in the implementation phases

In the event that the hazard reduction measures are not undertaken it is recommended that either:

- A sunset policy be applied to the affected area of the Commercial Centre A sunset policy be applied to the affected area of the Commercial Centre (excluding any future development or re-development which would be required to be compatible with the flood risks) OR
- The Wallsend Commercial Centre be relocated to flood free land.

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Floodplain Risk Management Study for the Wallsend Commercial Centre

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PROJECT 301015-00768 - FLOODPLAIN RISK MANAGEMENT PLAN FOR THE WALLSEND DISTRICT COMMERCIAL CENTRE

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for review	dmc	A Reviewer	N/A	13-Jan-09	N/A	
B	Reviewed by NCC	lk	BK,LK,DG		23Mar 09		
C	For Adoption by NCC				4 August 2009		

Floodplain Risk Management Study for the Wallsend Commercial Centre

1. INTRODUCTION

Flood impacts along Ironbark Creek have been studied for some time, culminating in the 'Wallsend Floodplain Risk Management Study and Plan' issued in draft in March 2007. This 'full study' was targeted at the entire catchment *(Wallsend Elermore Vale and Rankin Park)* and recommended a number of options for residential properties along with the Wallsend Commercial Centre. The current study (*this report*) was initiated in response to the June 2007 flood to focus exclusively on developing strategies to manage the risk to life in the Wallsend Commercial Centre should a similar or greater flood event occur.

Flooding is a natural process of any landscape and together with wind is the main driving force that shapes the land. Problems arise when floodprone land is developed and occupied leading to a redistribution of flood flows. Problems can also arise when ground surface characteristics are altered thus affecting the nature of flooding, that is less absorption and more rapid runoff.

Severe floods are rare and therefore a reasonable knowledge of flooding can only develop across generations. In more recent times this generational experience is augmented through scientific study of the processes and investigation of the outcomes. Centuries of experience in Europe has led to a good understanding of flooding and its consequences, and although development hasn't avoided the issue, the risks are reasonably well understood and accepted by the community.

With a lack of any local experience, early development in Australia had to be modelled on European knowledge of flooding in ignorance of the very different behaviour of rainfall and flooding prevalent here. The legacy of land acquisition and subsequent development now has to be managed within the context of our current experience and scientific study of Australian flooding behaviour.

This legacy has led unfortunately to some intractable situations where the risk of flood consequences is socially, environmentally or economically unacceptable, and solutions are needed to either live with and manage the risk, or if practical and feasible to modify the risks.

Wallsend Plattsburg's development dates back to the mid 19th century when a village was constructed by the Newcastle Wallsend Coal Company. Development progressed through the lower floodplain reaches of Ironbark Creek facilitated by access and the flatter topography. Towards the end of the century, the problems of local flooding had become apparent and in the 1890's a number of lined storm water channels were constructed to manage the passage of floodwater through the developed areas. Subsequent storm water drainage improvements in the intervening years have not alleviated the flooding problem, and the business district has flooded a number of times throughout the 20th century. The present flood risks in Wallsend Plattsburg are an integral part of its natural topography and the evolution of development within the floodplains and they have been recognised through recent study and investigation.

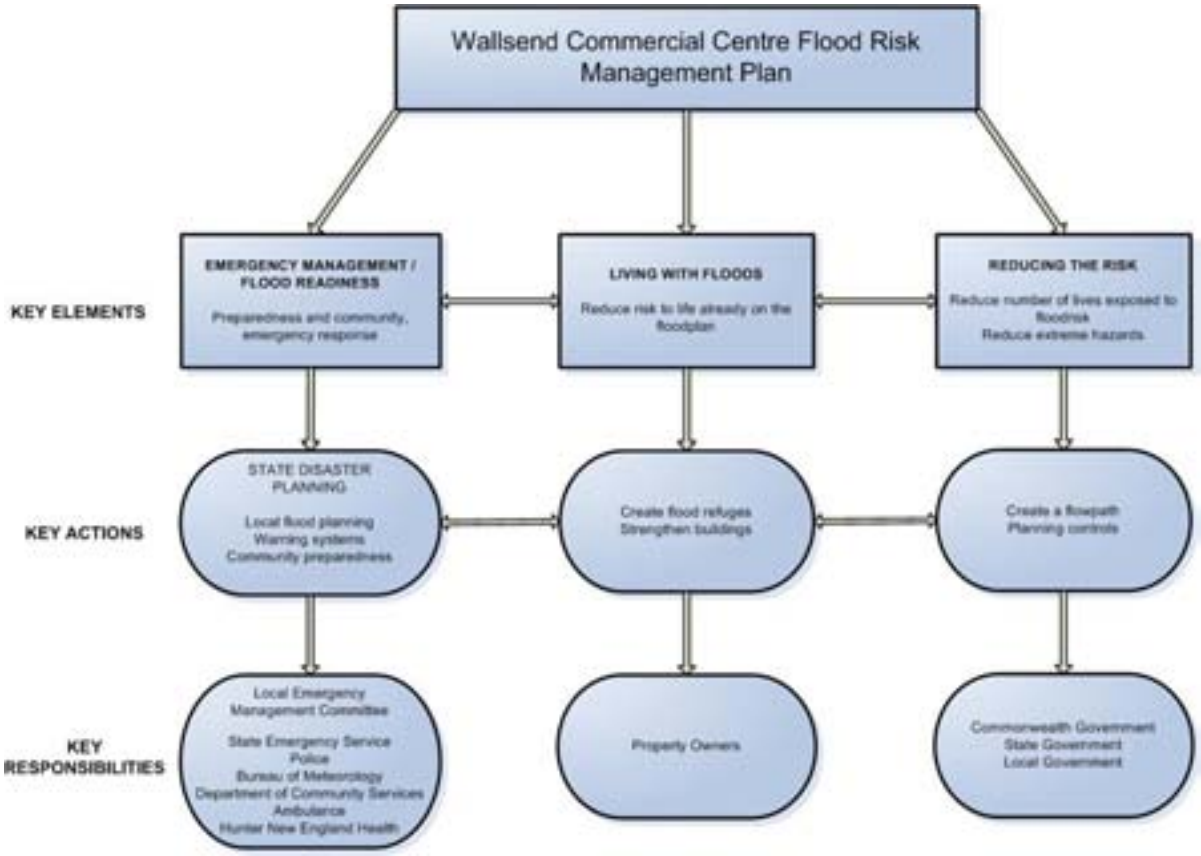
The Study and the Plan for the Wallsend Commercial Centre have been based on the recently completed draft of the full Ironbark Creek (Wallsend Plattsburg) Study, March 2007. It provides an historical overview of the flooding in the area (Section 2); examines the hazards in the area and the potential risk to life and property dependant on the severity of the flood (Sections 3 and 4) and the likely impact on the community (Section 5).

Potential measures identified by the community (Section 6) and during a workshop of experts convened in Wallsend on 6 February 2009 to manage risks during a flash flood are tested in Section 7.

Potential options have been grouped together according to:

- **Emergency Management and Flood Readiness** *(Local Emergency Management Committee / Emergency Agencies)*
- **Living with the Risk** *(Private Land Holders on Private Land)* AND
- **Reducing the Risk** *(Government works on Public Land and Planning Controls)*

This categorisation of potential options is shown in the table below:



It is proposed that Emergency Management and Flood Readiness implementation would be resourced and funded from emergency management agencies (such as the SES and Bureau of Meteorology), that “Living with Floods" measures (on private land) implementation would be funded by the property owners, and that implementation of “Reducing the Risk” measures would be funded by Government, all coordinated through an implementation Task Force.

2. IRONBARK CREEK

2.1 Geomorphic Setting

Before settlement in the catchment, the natural geomorphic setting of Ironbark Creek was characterised by a relatively narrow, low flow channel which meandered through a wide and flat floodplain before merging with the much larger expanse of Hexham Swamp. The edge of the floodplain gave way to fully vegetated catchment slopes. The catchment would have been relatively pervious and it would have absorbed considerable rainfall before the excess would have begun to runoff and onto the floodplain.

The substantial width of the natural floodplain compared to the width of Ironbark Creek can be seen in the 1944 photograph, **Figure 1**. Remnants of the natural meandering path of the Creek can be seen as relict meander scars on the floodplain.

In the natural order of things, when heavy catchment runoff exceeded the flow capacity of Ironbark Creek, water would overflow onto the floodplain and either flow overland and/or be stored temporarily until it could be conveyed downstream by the creek. The natural depth of these flood waters was a function of the intensity of catchment runoff and the combined discharge capacity of the creek and the adjacent overland flow paths.

Whilst the fully vegetated nature of the undeveloped catchment would have minimised the rate of rise and the depths of floodwater on the natural floodplain, it is important to appreciate that the smallness and relative steepness of the catchment have always caused floodwaters to rise rapidly and spill quickly from the channel onto the floodplain. Hence, even in the natural scheme of things, Ironbark Creek has always been predisposed towards fast rising, “flashy floods”.

2.2 Wallsend Historic Overview

Newcastle City Council recognises aboriginal peoples *(in this area Awabakal and Worimi)* as traditional custodians of the country. Before Ironbark Creek and adjacent extensive wetlands were taken up for agricultural settlement by several European families in the 1820’s and 1830’s, aboriginal peoples would have experienced the natural catchment including a wide range of floods over time.

European settlement initially established two townships, one on each of the two hills either side of the natural creek and floodway flowing into what is now known as Hexham Swamp. Wallsend was built on the eastern hill when coal bearing land in the vicinity was discovered and the Newcastle Wallsend Coal Mining Company was formed in 1858/9. Wallsend soon established a distinctive identity, and elaborate hotels and shops developed in Cowper, Murnin and Metcalf Streets as Scottish, Northumberland and Welsh Miners came to the area. Plattsburg was built on the western hill after a cooperative coal mining company under the management of James Fletcher was opened in 1865 on land leased by striking miners from Minmi.

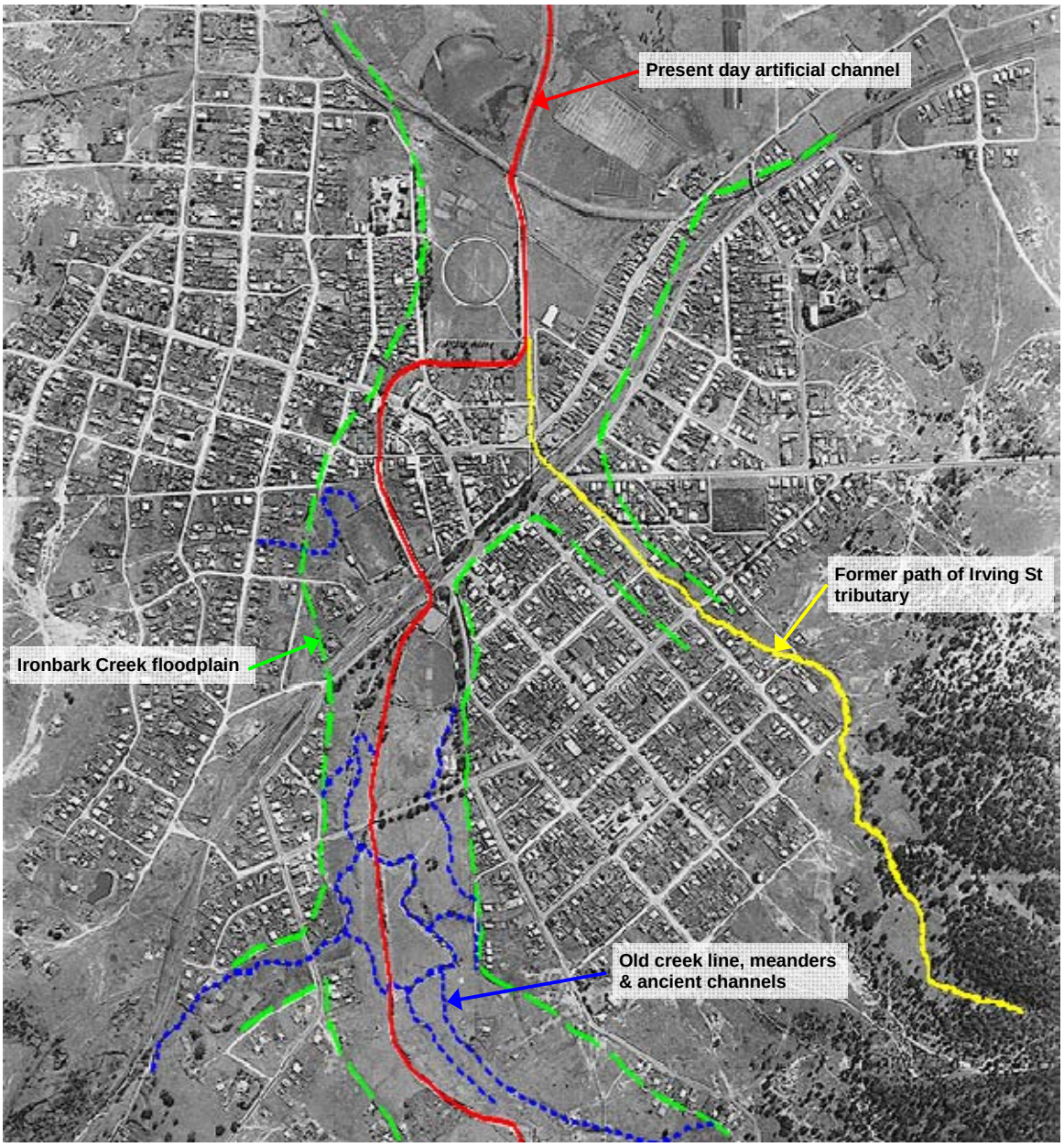


Figure 1 - 1944 Aerial Photo with Geomorphic Features Highlighted

The commercial centres of the two communities – Wallsend and Plattsburg – were originally on high ground out of reach of flooding separated by partly swampy land used as an athletic ground. In time, a road was built though this land which became Nelson Street. From about 1870, something of a building boom lined Nelson Street with many elaborate Victorian premises, including Cooperative Society retail stores, becoming one of the busiest streets in the Newcastle district. Many hotels were later converted to business premises. There was limited recognition of flooding when many shops

and hotels were built several steps higher than the road, but major floods were found to still enter some shops by a metre or so.

Coal mining began to decline from the 1930's and the 1950's saw rapid expansion of population when former mining land was released for residential development. The upper parts of the catchment have been substantially developed with mainly residential development in the following decades.

2.3 Historical Floods

Early flood records highlight that Ironbark Creek is no stranger to flooding:

1864: Creeks lagoons and swamps were filled to overflowing. The bridge across Ironbark Creek 'was laid prostrate by the flood' being 'completely overturned' *(8 June 1864 Unidentified Newspaper)*.

1889: 'Portions of Boscawen and Council Streets … were washed away,...as the water rushed down ... with great force.' 'Mr Penrose house in Harris Street was completely surrounded by water which compelled him to remain indoors.' Nelson Street shops were reported to have flood damage *(28 May 1889 Newcastle Morning Herald and Miners Advocate)*.

1890's: Some concrete stormwater channels in the lower portions of Wallsend were constructed.

1895: "…the continuous downpour of rain has resulted in the lower portion of Nelson Street being flooded *(23 Jan 1895 Newcastle Morning Herald and Miners Advocate)*.

1897: There was a Royal Commission into the drainage of Wallsend Plattsburg.

1908: … bridges have been washed away.' 'John Street … was … in a state of flood,... several of the residents were taken from their houses in a boat and landed on higher lands adjoining.' 'The water in Council Street, at the rear of the Nelson Street properties … had a depth of not less than three and a half feet.' 'At Boscawen Street the bridge over the Stormwater drain was submerged, … All the flats on either side of the drain *(were)* submerged. Federal Park … had … three feet of water upon it.' *(24 February 1908 Newcastle Morning Herald and Miners Advocate, and 24 February 1908 Unidentified Newspaper, and 25 Feb 1908 Newcastle Chronicle)*.

1920: 'An immense body of water rushed into the stormwater drain … It became evident that the drain would not carry off the great volume of water, and … it overflowed its banks and entered the business places in … of Nelson Street ... (causing)...considerable damage. .The plate glass window of Mr Davies' grocery store collapsed, and in the Co-operative Society's drapery branch the water rose almost to the height of the counter. In Mr James' boot store the water was three feet deep ....' *(10 December 1920 Newcastle Morning Herald and Miners Advocate)* .

1927: ' (Flood waters) entered … the buildings in … Nelson Street...up to a foot or so. In Council Street ... there was a depth of five feet. The mark left on the window ... at the Corner of Council and Tyrrell Street was four feet above the footpath. ... The whole of the bridge piles of the Cardiff road bridge near the Chinese Gardens at South Wallsend were carried away.' *(18 April 1927 Newcastle Morning Herald)*.

1937: Properties at the lower end of Irving Street Wallsend were reported to have flooded despite stormwater drainage improvements a few years earlier.. *(4 Jan 1937 Newcastle Morning Herald)*

1946: 'The lowest part of Wallsend business centre was flooded yesterday. In Council Street near the channel the water reached depths of four to seven feet. ... Water flowed through the factory of Bramco Radio components ..... The Nelson Street Bridge was covered. ....' *(19 April 1946 Newcastle Morning Herald)*.

1988: There was extensive flooding through out many reaches of the Ironbark Creek catchments and much of the urbanised areas were severely affected.

1990: There was extensive flooding again. The flooding was similar, but not quite as severe as the 1988 event.

2007: 'The storms of the June 2007 long weekend, particularly on Friday 8th, caused widespread flash flooding across Newcastle City.' (*June 2007 Flood Data Compendium, BMT WBM*).

2.4 Wallsend Plattsburg Flood Study

Explanation of a Flood Study

A Flood Study constitutes the major technical foundation of decision making and is carried out before options to manage the flood hazards are investigated by a Floodplain Risk Management Study (this Study) and a Flood Risk Plain Management Plan is developed.

A Flood Study is a comprehensive technical investigation of flood behaviour that defines the variation over time of flood levels, extent and velocity for floods of various severities up to and including the PMF. The heart of this technical investigation is the development of a rainfall and flood behaviour model specific to the rainfall patterns, catchment, topography and development in the study area. Typically complex numeric rainfall and flood behaviour models using computers are built by specialists. The computer results of these models are complex and highly technical requiring visual displays to enable interpretation and use by the community and professionals who manage the hazards.

Although there are uncertainties in the development and use of any flood model, flood models are essential for decision making. They enable flood hazards and community consequences to be estimated – including the very real prospect of floods which are more severe than already experienced up to the worst case scenario (*the PMF*). Flood models are also the only means available to estimate the consequences of future development and to estimate the effectiveness of options to manage the hazard.

The Wallsend Plattsburg Flood Study

The catchment that feeds the study area has historically been known as the Wallsend Plattsburg catchment. The Wallsend Plattsburg Flood Study and the computer model built by that Study have been confirmed against the observed floods of June 2007, April 1988 and February 1990, and used in the development of this Wallsend District Commercial Centre Floodplain Risk Management Study and Plan. This model is a complete revision of previous modelling undertaken in support of the recent full Ironbark Creek (Wallsend Plattsburg) Flood Risk Management Study and Plan, Draft - March 2007.

Results Display

The results of the previous flood model developed for the recent full Ironbark Creek Flood Risk Management Study were shown interactively to the community during the exhibition and consultation phase of the previous Study as well as to the Newcastle Flood Risk Management Committee. The results were displayed by the proprietary computer flood mapping tool waterRIDE™ (waterRIDE.net). This display tool was found to be very powerful in facilitating the understanding, communication and analysis of the flood risks, hazards and management options.

The results of the current flood model, including scenario testing for various impacts and mitigation measures have likewise been workshopped with the Newcastle Flood Risk Management Committee.

2.5 Flooding: Legacy of Urbanisation

As noted above, the flood risks of the Wallsend catchment are the legacy of settlement which has dramatically changed the behaviour of the catchment.

Over the last 100 years or so, the catchment slopes have been heavily urbanised and the roofed and paved areas have increased catchment runoff. Ironbark Creek has been channelised and largely cleared of riparian vegetation. As a consequence, the catchment slopes are delivering greater quantities of catchment runoff *(i.e. increased peak discharges)* to the floodplain quicker than the natural order of things.

This distortion of the natural order has been compounded by development which has in-filled the floodplain, directing flood flows to the low flow channel which is manifestly unable to cope without causing an increase in flood levels.

Figure 2 shows the flood extents of both of the 1 in 100 annual chance flood and the PMF throughout the length of Ironbark Creek. By and large, the 1 in 100 annual chance flood is confined to the natural floodplain and it embraces significant areas of development only where the natural floodplain has been in-filled by development. Much the same can be said for the PMF except that additional urban areas are inundated along the fringe of the natural floodplain because of the much greater depths involved.

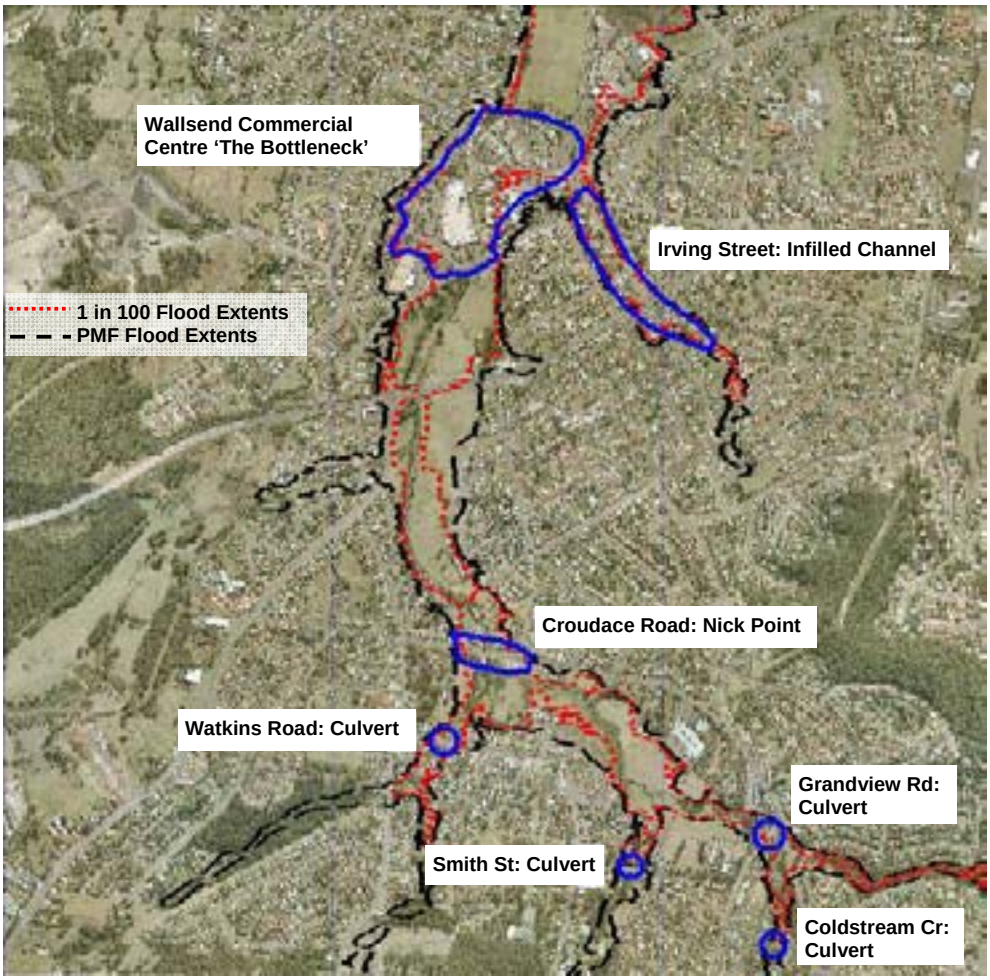


Figure 2 - 1 in 100 Annual Chance and PMF Flood Extents Showing Constrictions

The Wallsend Commercial Centre presents a significant floodplain constriction between Wallsend Park and Federal Park, where the creek is confined to a narrow concrete lined channel. On both sides of the channel, commercial buildings act as a barrier to overbank flood flows. In effect, the shops and other commercial buildings act like a dam causing large floods to build up a 'head' of water upstream of Nelson St to push the flow through. This build up creates the energy to force floodwater along the streets and through the carparks of the business district i.e. the streets are default flood paths. In large floods the flow through the streets and carparks can be fast moving with strong and dangerous current.

During the 1988 and 1990 floods, which have been estimated to be about 1 in 10 to 1 in 15 annual chance floods *(DHI 2008)*, the backup in water level behind the shops in Nelson St was measured as 0.5m. The June 2007 flood is estimated as a 1 in 40 to a 1 in 100 chance flood through the commercial district (*DHI 2008*) where depths reached 1.5m in the area behind the shops along Nelson Street. Modelling shows this figure can well exceed 1.5 metres in very large floods.

2.6 Flash Flooding: Fast Rates of Rise

As noted above, the Wallsend catchment is naturally predisposed to flashy floods with a fast rate of rise. Development of the catchment has accentuated this natural propensity and, over time, flood flows in Ironbark Creek and its tributaries have become flashier. Many long term residents have reported that the rate of rise of floodwaters in the Creek from shallow flow, at the start of runoff to bank full is quicker than it used to be.

The great majority of coastal rivers in NSW have rates of rise which are generally less than 1m/hr and seldom more than 2m/hr in rare events. **Figure 3** shows the variation of water level with time at Tyrrell Street, as determined by Council's flood model *(DHI 2008)*. The rates of rise are determined as the slope of the rising limb of the curves.

It can be seen that even the more frequent floods have a rate of rise in excess of 1m/hr. In the rarer floods, the rates of rise can exceed 3m/hr and reach up to 7m/hr. These extremely fast rates of rise produce floods which can catch people unawares and trap them in life threatening situations. These characteristics separate flash flooding from the majority of floods in NSW.

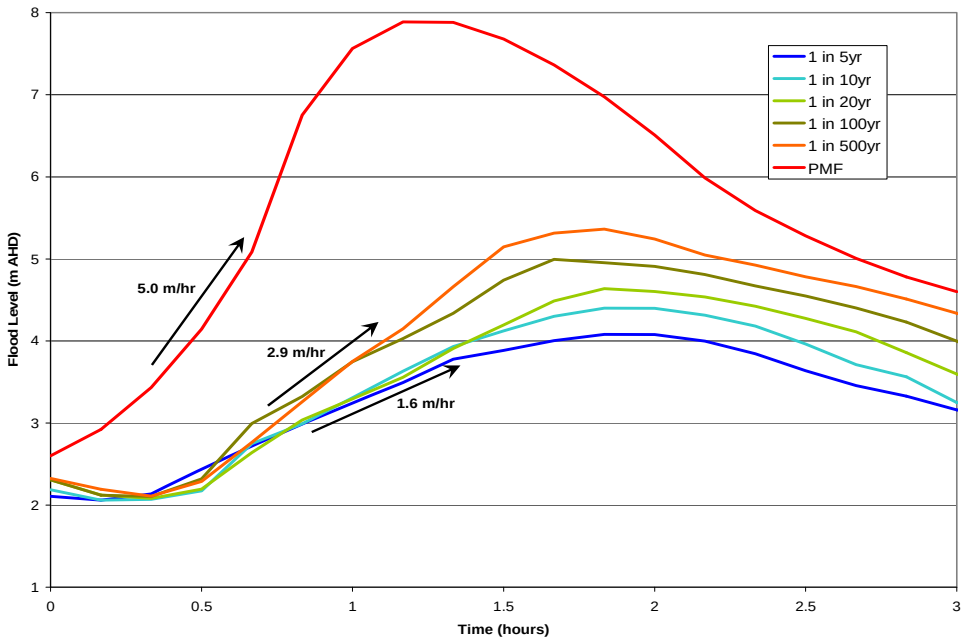


Figure 3 - Rates of Rise of Floodwater in Ironbark Creek at Wallsend Commercial Centre

The risk to life posed by flash floods in the Wallsend Commercial District is demonstrated in the following section.

2.7 The Risk to Life Associated With Flash Flooding

Notwithstanding that urbanisation has dramatically altered the natural order of things, in relation to flood behaviour, it is the predisposition of the Wallsend catchment to flash floods that makes the legacy of development life threatening. This can be appreciated by considering the rapid escalation of flood hazards which can occur in selected areas of the floodplain. Council's Flood Study *(DHI 2008)* provides, for the first time, an understanding of the time sequence of the development of flood hazards throughout the catchment. Peak flood hazards are discussed in **Section 3.1**.

The Flood Study shows that the time from the start of rainfall until Ironbark Creek is running bank full can be as little as 10 minutes in the upper catchment and 20-40 minutes in the Commercial Centre. These times are too fast for any effective flood warning to be made by the Bureau of Meteorology with currently available technology. Hence, the first indication that the average person is likely to have that a flood is imminent is when Ironbark Creek begins to overtop its banks.

1 in 100 annual chance flood

Prior to Ironbark Creek overtopping its banks, floodwaters from the local catchment west of the Plaza would develop sufficient energy to affect cars along Kokera St and the small carpark south of the shopping centre. From the time Ironbark Creek begins overtopping its banks in the Commercial Centre, it would take:

- **15 minutes** for the water depth in the low lying areas of Council St to reach 0.8m causing all cars in the car park to float *(cars begin floating at a depth of approximately 0.3m-0.4m)*. Flow conditions would be too dangerous for wading by an able-bodied adult. Anyone trapped in their car would be in danger. Depth in Tyrrell St would be 0.5m preventing passage of a light family car;
- **30 minutes** for the water depth in Tyrrell St to reach 1.0m and flow conditions in Tyrrell St to become too dangerous for wading by a healthy adult. Floodwaters would begin flowing down Nelson St;
- **35 minutes** for flows in Nelson St to destabilise cars and floodwaters to just overtop Cowper St and begin flowing into the Plaza car park and combine with floodwaters from the small tributary west of the Plaza flowing down Kokera St;
- **50 minutes** for floodwaters crossing over Cowper St to commence flowing through the main Plaza carpark, and flows to connect through Tyrrell St and into Harris and William Streets;
- **60 minutes** In the ten minutes *(i.e. between 50 and 60 minutes from initial overtopping)* water depth in the main Plaza car park would quickly build up to 0.4 to 0.7 metres causing most cars to float and drift towards the downstream end of the carpark where they would likely form a blockage. Flow conditions along Nelson St would be too strong for a healthy adult to wade i.e. people would be trapped in shops. Depths in Tyrrell St either side of the channel would exceed 1.5 metres. Depths along Council St at the rear of the shops maybe sufficient to affect the structural integrity of any of the older or poorly constructed buildings;
- **75 minutes** for the flood to peak and flow conditions to worsen slightly. At the peak, 28% of the flow would be passing through the Plaza carpark.

1 in 500 annual chance flood

In rarer floods the impacts are increased and the times are shortened. For example, during a 1 in 500 annual chance flood, from the time Ironbark Creek begins overtopping its banks in the Commercial Centre, it would take:

- **10 minutes** for the water depth in the low lying areas of Council St to reach 0.8m causing all cars in the car park to float *(cars begin floating at a depth of approximately 0.3m-0.4m)*. Flow conditions would be too dangerous for wading by an able-bodied adult. Anyone trapped in their car would be in danger. Depth in Tyrrell St would be 0.5m preventing passage of a light family car. Floodwaters from the small catchment west of the plaza would overflow into the main carpark causing some cars to float;
- **20 minutes** for the water depth in Tyrrell St to reach 1.0m and flow conditions in Tyrrell St to become too dangerous for wading by a healthy adult. Floodwaters would begin flowing down Nelson St;
- **25 minutes** for flows in Nelson St to destabilise cars and floodwaters to just overtop Cowper St and begin flowing into the Plaza car park and combine with floodwaters from the small tributary west of the Plaza flowing down Kokera St;
- **35 minutes** for floodwaters crossing over Cowper St to commence flowing through the main Plaza carpark, and flows to connect through Tyrrell St and into Harris and William Streets;
- **40 minutes** in the five minutes *(i.e. between 35 and 40 minutes from initial overtopping)* water depth in the main Plaza car park would quickly build up to 0.4 to 0.9 metres causing most cars to float and drift towards the downstream end of the carpark where they would likely form a blockage. Flow conditions along Nelson St would be too strong for a healthy adult to wade i.e. people would be trapped in shops. Depths in Tyrrell St either side of the channel would exceed 1.6 metres. Depths along Council St at the rear of the shops maybe sufficient to affect the structural integrity of any of the older or poorly constructed buildings;
- **65 minutes** for the flood to peak and flow conditions to worsen slightly with flows along Tyrrell St connecting through to Low St. At the peak, 31% of the flow would be passing through the Plaza carpark.

Probable maximum flood

Whilst the probable maximum flood (*PMF*) is extremely rare, it is an indicator of the ultimate affect that a flood can have on a community. In the Wallsend Commercial Centre the PMF sees flood conditions worsen considerably and times shorten dramatically over the 1 in 500 annual chance flood.

The channel will overtop its banks sooner after heavy rainfall has commenced and within 20 minutes after overtopping, flow conditions *(depth and velocity)* would be too dangerous for wading by a healthy adult along Tyrrell St, Nelson St and within the Plaza carpark. Anyone trapped in their car would be at risk of drowning and people would be trapped in the shops and offices along many of the Commercial Centre streets. These highly dangerous conditions would develop over a timespan as little as 5 to 10 minutes.

The ultimate conditions in the heart of the business district at the peak of the PMF flood (*depths from 2.5 to 5m and velocities exceeding 1 m/sec*), 70 minutes after the channel overtopped its banks, would be sufficient to cause structural damage to most of the buildings, including the Plaza shopping centre. Many of the people trapped in these buildings would most likely perish.

At the peak of the PMF, 49% of the flow passes through the Plaza carpark and 19% of the flow passes through the streets east of the channel (*Council, Nelson, Dan Rees and Kemp Sts*).

Summary

Flash floods in the Wallsend catchment occur with no effective warning. The larger floods can rapidly envelope buildings with deep and swiftly flowing water which is too dangerous for self-directed evacuation by wading. People can be trapped in buildings with the enclosing floodwater rapidly increasing in energy to the point where the buildings can sustain extensive structural damage. Many buildings could collapse, drowning those trapped in them. The rapid escalation of the energy of the enclosing waters means that it would be extremely dangerous for rescue attempts.

2.8 Ironbark Creek Floodgates

A review of tail water levels in Hexham Swamp and their effect on flood levels upstream of Minmi Road was undertaken to assess the sensitivity of operation of the Ironbark Creek floodgates on flooding within the Wallsend Commercial Centre.

There is a significant headloss or steep water surface slope through Minmi Road Bridge and model sensitivity testing shows that tail water levels downstream of Minmi Road less than 2m AHD (*the level at which the highway is overtopped*) are consumed by the headloss at the bridge and have no effect upstream.

The storage volume in Hexham Swamp up to this level (*RL2m*) is approximately 30 million cubic metres, whereas the 1 in 100 annual chance flood in Ironbark Creek has a runoff volume of 1.4 million cubic metres, and the PMF has a runoff volume of approximately 5 million cubic metres. Thus there is ample capacity in Hexham Swamp to store the entire volume of any Ironbark Creek flood without any impact upstream of Minmi Road even if there is a solstice spring or king tide present at the time of the flood.

Thus gate operation will have no impact on flooding within the Wallsend Commercial Centre. Hunter River flooding will, however, have an impact once the highway becomes overtopped and Hexham Swamp fills to above 2m AHD.

2.9 Hunter River Flooding

The Wallsend Commercial Centre can be subject to flooding from the Hunter River. In contrast the extraordinary potential flash flood risk to life, the potential risk to life from Hunter River flooding – even for the worst case scenario - is considered low, since the nature of flooding from the Hunter River is fundamentally different.

Hunter River flooding arises from a very large catchment that takes a long time – measured in days – to be mobilised. There is generous warning available – also measured in days. With ample time for emergency services to notify and evacuate people from the Wallsend Commercial Centre it is reasonable to expect no people would be present in the Commercial Centre during the otherwise life threatening phases of a Hunter River flood.

Since Hunter River flooding (when managed by Emergency Agencies with appropriate flood readiness) does not pose an extreme risk to life, potential risks from Hunter River flooding in the Wallsend Commercial Centre will be considered as part of the development of a Floodplain Risk Management Plan for the entire Newcastle local government area which is being developed over the next eighteen months.

Flood mapping from the computer modelling estimating the worst case Hunter River flood scenario (the PMF) is presented below. This mapping shows the estimated depths could reach nearly 4 metres in some locations of the Commercial Centre.

Figure 4 - Hunter River flooding – estimate of worst case (PMF) - Wallsend Commercial Centre

Flood mapping from the computer modelling estimating the 1 in 100 annual chance Hunter River flood scenario is presented below. This mapping shows the estimated depths could reach nearly 1.5 metres in some locations of the Commercial Centre. More typically, such as in Nelson Street, the estimated depth would only be “shin deep” – which roughly corresponds with verbal reports of the February 1955 Hunter River flood being up to “peoples’ knees” in Nelson Street.

Figure 5 - Hunter River flooding – estimate of 1 in 100 annual chance event) - Wallsend Commercial Centre

2.10 Potential Climate Change

High range sea level rise estimates under current NSW Department of Environment and Climate Change Guidelines, if permitted to propagate in to the Wallsend catchment, would be completely contained in the existing concrete lined channels within the Commercial Centre.

The high range sea level rise scenario water levels are very similar to the simulated high tail-water levels for Hexham Swamp used for computer flood modelling for sensitivity to increased water level levels in Hexham Swamp *(see Section 2.8)*. Since this simulation concluded there would be no impact on flash flooding in the Wallsend Commercial Centre it is reasonable to similarly conclude high level sea level risk estimates would also have no impact on flash flooding in the Wallsend Commercial Centre.

It is possible that changes in future climate may increase the likelihood / frequency of extreme weather events. This reinforces the imperative to take steps to manage the risks to life in the Wallsend Commercial Centre.

3. FLOODPLAIN HAZARDS

3.1 Flood Hazard Categories

3.1.1 Provisional Hydraulic Categories

The first step in understanding floodplain hazards is to examine the variation of the hydraulic variables of depth and velocity that can occur across the floodplain in response to different probability floods. The FDM *(DIPNR, 2005)* recommends the identification of two provisional hydraulic hazard categories based on the peak values of velocity and depth, viz:

High Hazard: possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty in wading to safety; potential for significant structural damage to buildings.

Low Hazard: should it be necessary, truck could evacuate people and their possessions; able-bodied adults would have little difficulty wading to safety.

The Manual *(DIPNR, 2005)* specifies velocity and depth criteria to facilitate the determination of the provisional hydraulic categories.

In **Figure 6**, these provisional hydraulic categories have been applied to the 1 in 100 annual chance flood and the PMF for the Wallsend Commercial centre. The results for both floods are based on a time of concentration of 2hrs, which corresponds to the critical storm duration for the Wallsend Commercial Centre as determined by the Flood Study *(DHI 2008)*.

Figure 6 shows that in relation to the 1 in 100 annual chance flood, under existing conditions, the provisional hydraulic hazards are high only through the channel, some of the streets behind the shops along Nelson Street, and across the playing field and park areas. Up until the 1 in 100 annual chance flood, the limit of flooding is largely confined to the floodplain, and it is only in the core of the Commercial Centre that the “bottleneck” is manifest as expanded flooding in the streets.

It can be seen that in relation to the PMF, almost the entire floodplain throughout the Commercial Centre is high provisional hazard. The Plaza carpark becomes a major overland flow path with half of the total flood flow passing through the car park at the peak of the PMF.

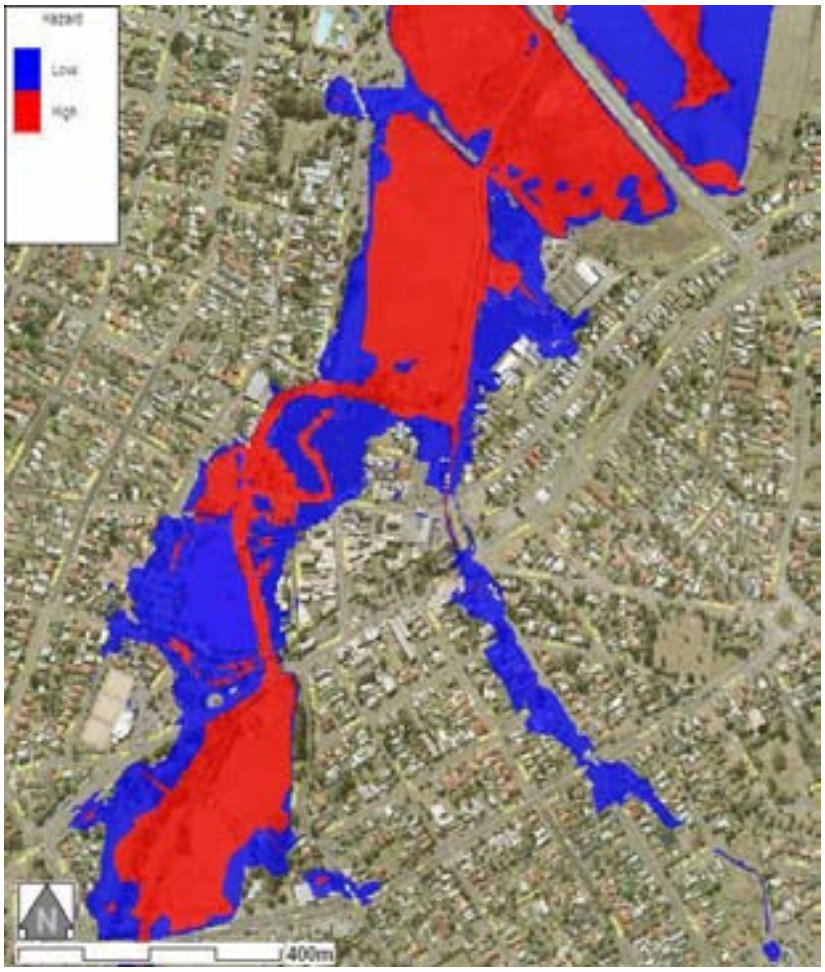


Figure 6 – Commercial Centre 1 in 100 (left) & PMF (right) Provisional Hydraulic Categories

3.1.2 Review of Provisional Hydraulic Hazard Categories

The provisional hydraulic hazard categories consider only the pure hydraulic variables at the peak of each design flood. The Manual *(DIPNR, 2005)* requires the provisional hydraulic hazard categories to be reviewed in the light of the full time varying nature of the flood hazards with particular attention to matters such as flood warning, evacuation routes and flood awareness.

It is the time varying nature of flood hazards which dictate the actual risk to life and property. For instance, if there is considerable warning time, the risk to life can be largely removed by evacuation to flood free land and avoidable flood damage to household goods *(or stock)* can be minimised through appropriate flood preparations. This is in complete contrast to a flood situation where there is virtually no warning time and people and their belongings can be trapped by fast rising flood water.

The provisional hydraulic hazard categories are revised in the following section.

3.1.3 Revised Hydraulic Categories (i.e. Hydraulic Behaviour Thresholds, Newcastle DCP 2005)

The dominant feature of the time varying behaviour of floods in the Wallsend Catchment is that they are flash floods. As noted earlier it can be as little as twenty minutes before flow overtopping the banks of Ironbark Creek and flowing into the streets of the Wallsend Commercial Centre, becomes too dangerous for wading *(even less time for safe vehicle passage)*.

Wallsend is a flash flood catchment. This means that there is little to no warning time and no time for the execution of a formal community evacuation plan. Self directed evacuation is the only effective action possible and there would be great risk to the lives of people trapped in a family car by rapidly rising flood water.

Because of the lack of effective warning time, many people will be forced to see out the flood in buildings i.e. residential dwellings or commercial premises in the Commercial Centre. The risk to life would be extreme if the building could be destroyed by the power of the surrounding flood water.

Because flash floods in Newcastle can trap people in buildings, Council, through development controls *(Newcastle DCP 2005)*, has subdivided the two provisional hydraulics hazard categories into the following five "hydraulic behaviour thresholds". These five thresholds define an escalating scale of hazards in which the risk to life and property become more acute:

H_1 - hydraulically suitable for parked or moving cars
$V < 0.5$m/sec and $d < 0.3$m

H_2 - hydraulically suitable for parked or moving heavy vehicles and wading by able-bodied adults
$V < 2$m/sec, $d < 0.8$m and $v < 3.2 – 4*d$

H_3 - hydraulically suitable for light construction *(eg. timber frame and brick veneer)*
$v < 2$m/sec, $d < 2$m, $v*d < 1$

H_4 - hydraulically suitable for heavy construction *(eg. steel frame and reinforced concrete)*
$v < 2.5$m/sec, $d < 2.5$m and $v*d < 2.5$

H_5 - generally unsuitable.

Figure 7 to **Figure 12** show the distribution of the peak hazards *(H_1-H_5)* associated with all the design floods *(i.e. 5, 10, 20, 100, 500 annual chance floods and PMF)*. In broad overview, the distribution of H_1-H_5 can be described as follows:

In relation to floods up to the 1 in 100 annual chance, a small area of H_3, near the concrete channel in Council and Tyrrell Sts, progressively grows with increasing flood size to envelope this area behind the shops along Nelson Street. At the 1 in 100 annual chance flood the flowpath from Tyrrell Street into Nelson and Boscawen Streets also becomes H_3 and a small area of H_4 develops along Council Street at the rear of the shops resulting from increased depth. The Plaza carpark areas predominantly remain H_1 to H_2. The 1 in 500 annual chance flood sees the hazards in all these areas generally raised by one category. The core of the Commercial Centre is H_5 in a PMF surrounded by a zone of H_4, whilst the fringes are H_3.

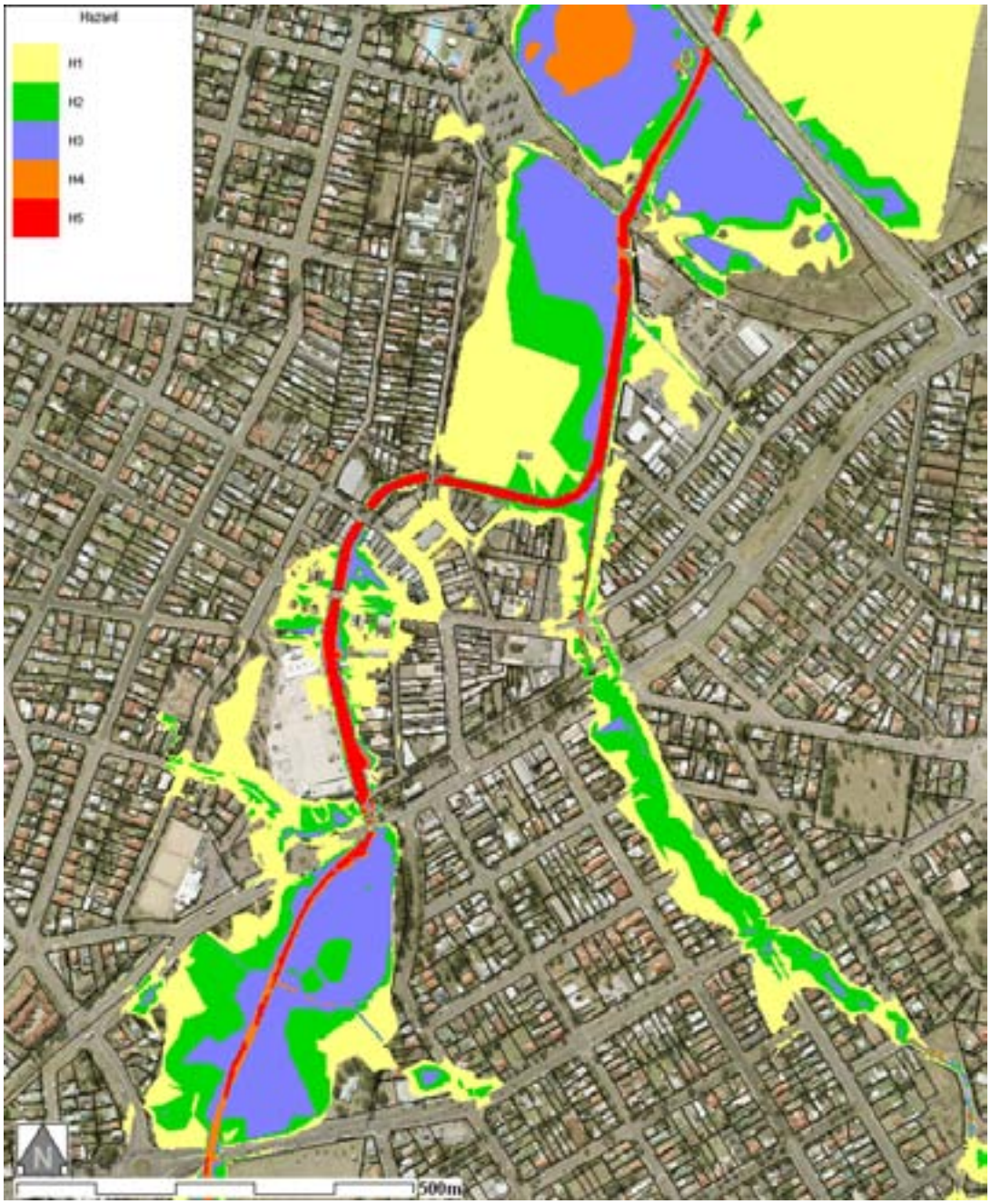


Figure 7 - Commercial Centre Peak Hazards - 1 in 5 Annual Chance Flood

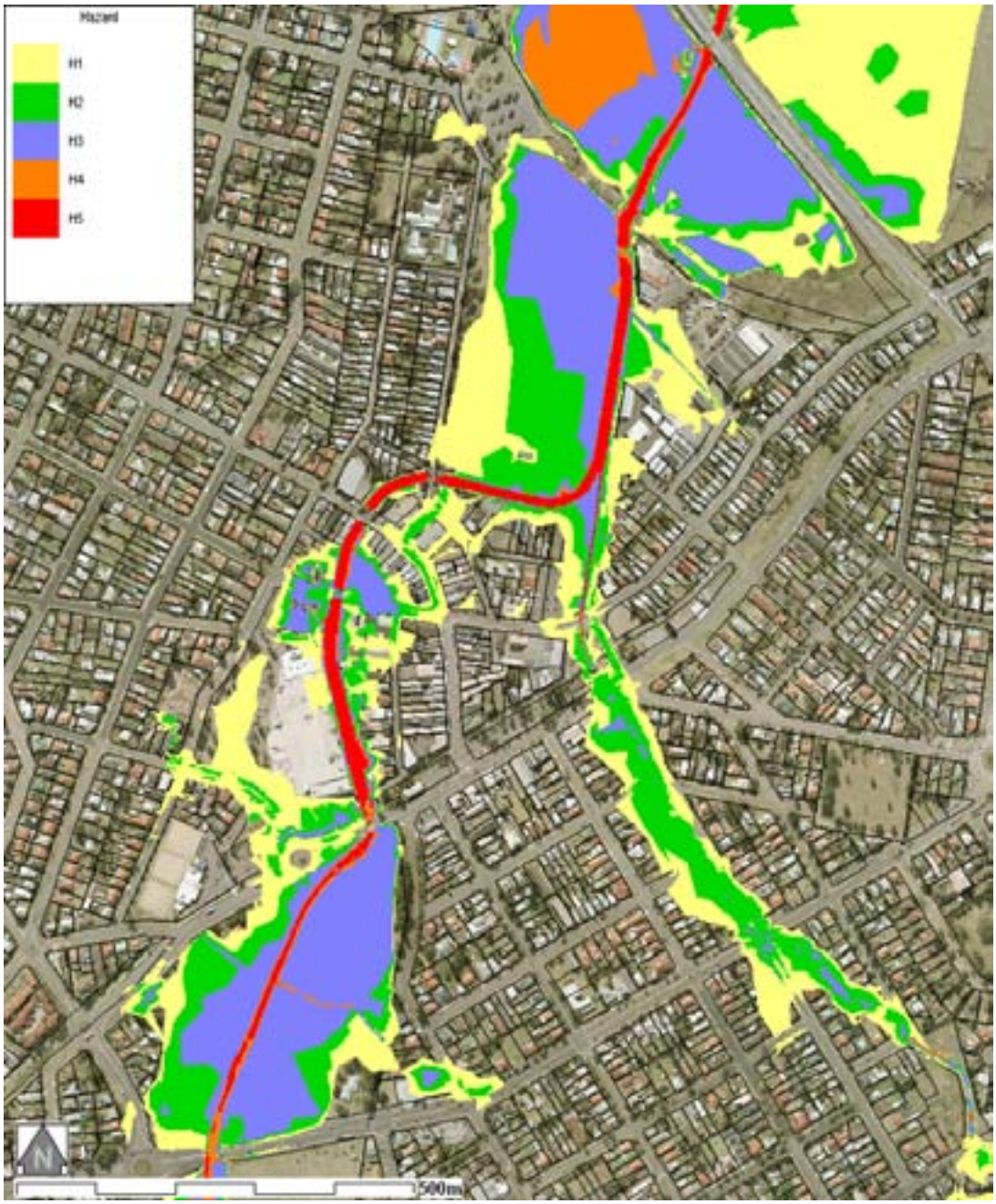


Figure 8 - Commercial Centre Peak Hazards - 1 in 10 Annual Chance Flood

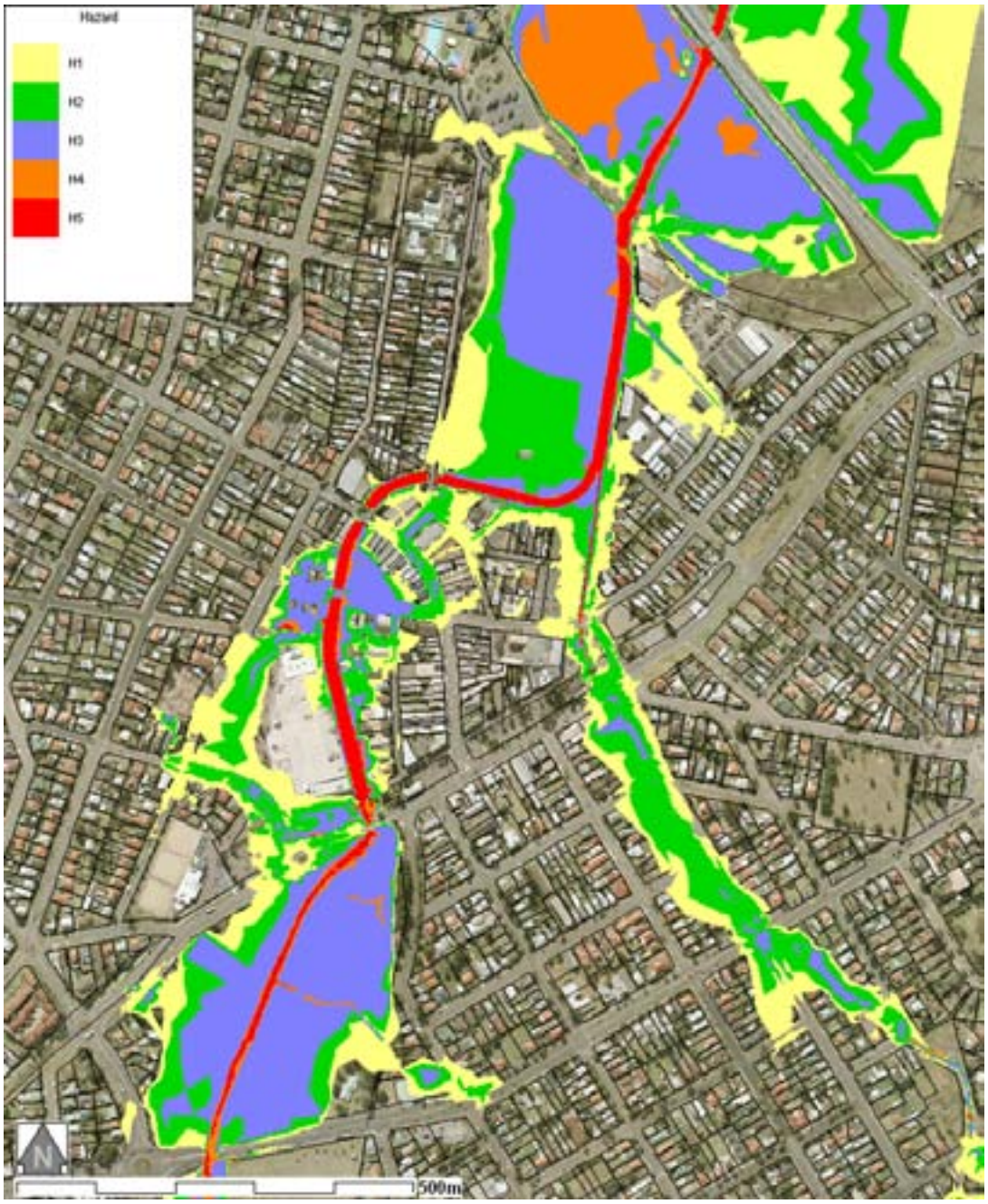


Figure 9 - Commercial Centre Peak Hazards - 1 in 20 Annual Chance Flood

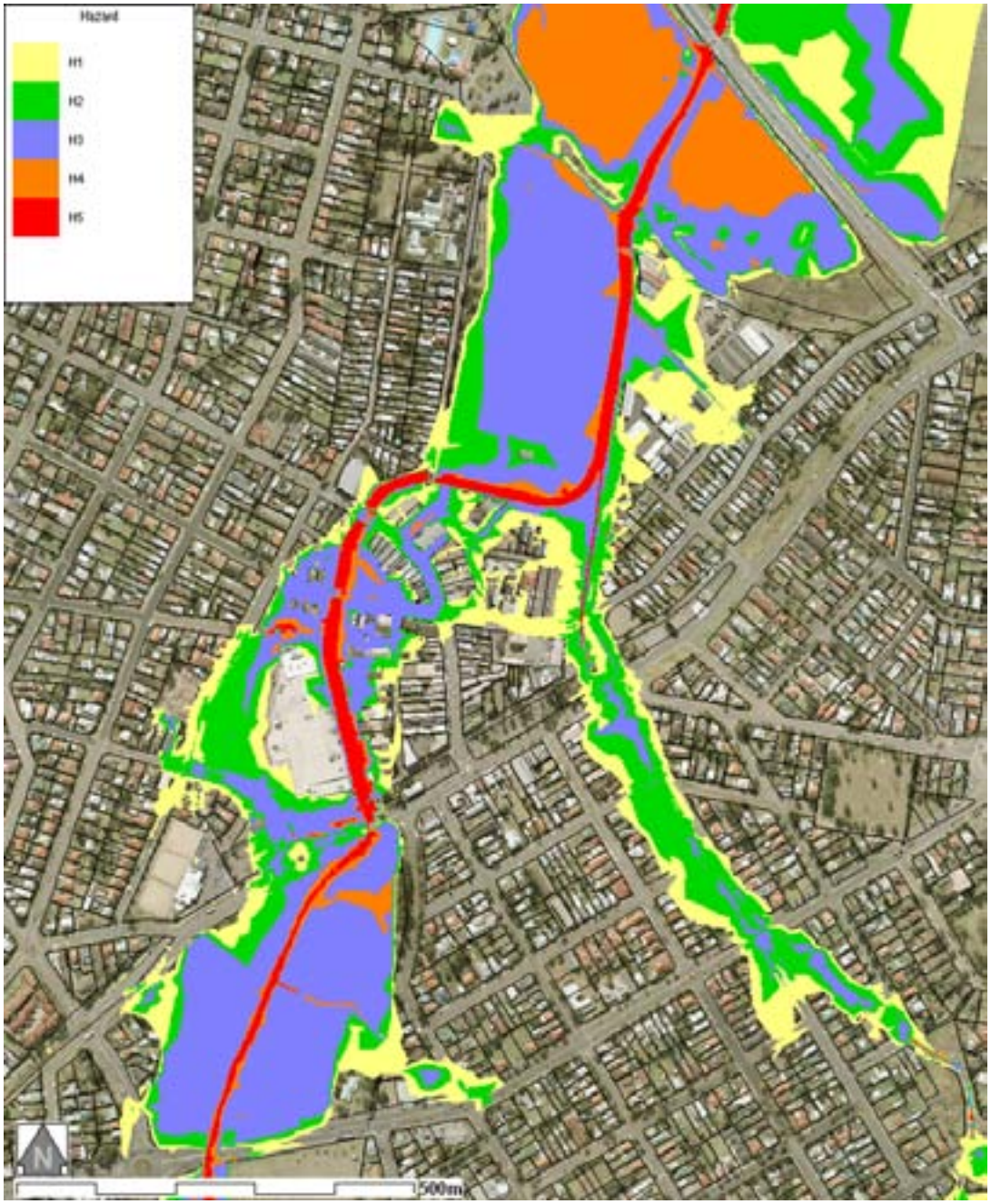


Figure 10 - Commercial Centre Peak Hazards - 1 in 100 Annual Chance Flood

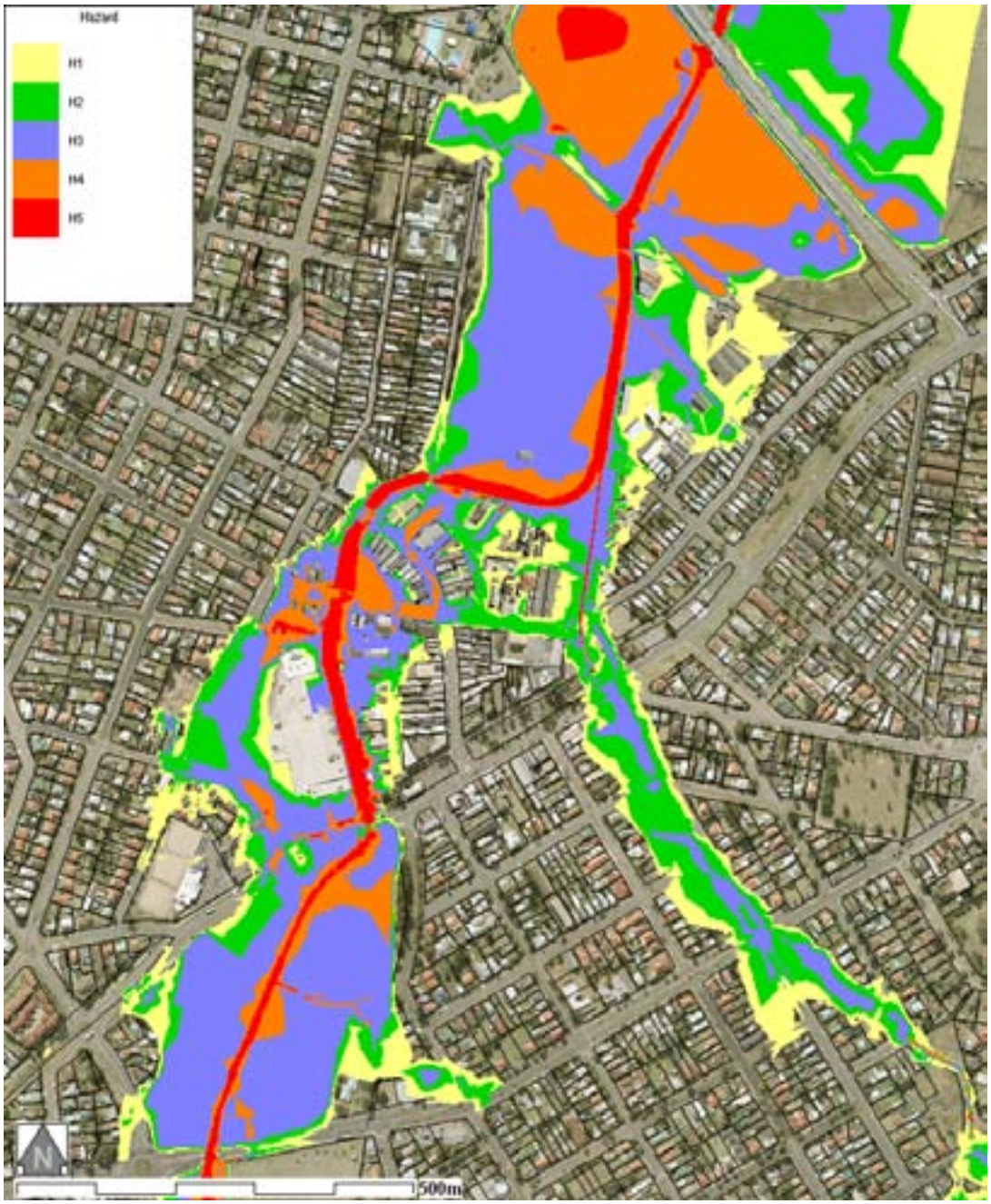


Figure 11 - Commercial Centre Peak Hazards - 1 in 500 Annual Chance Flood

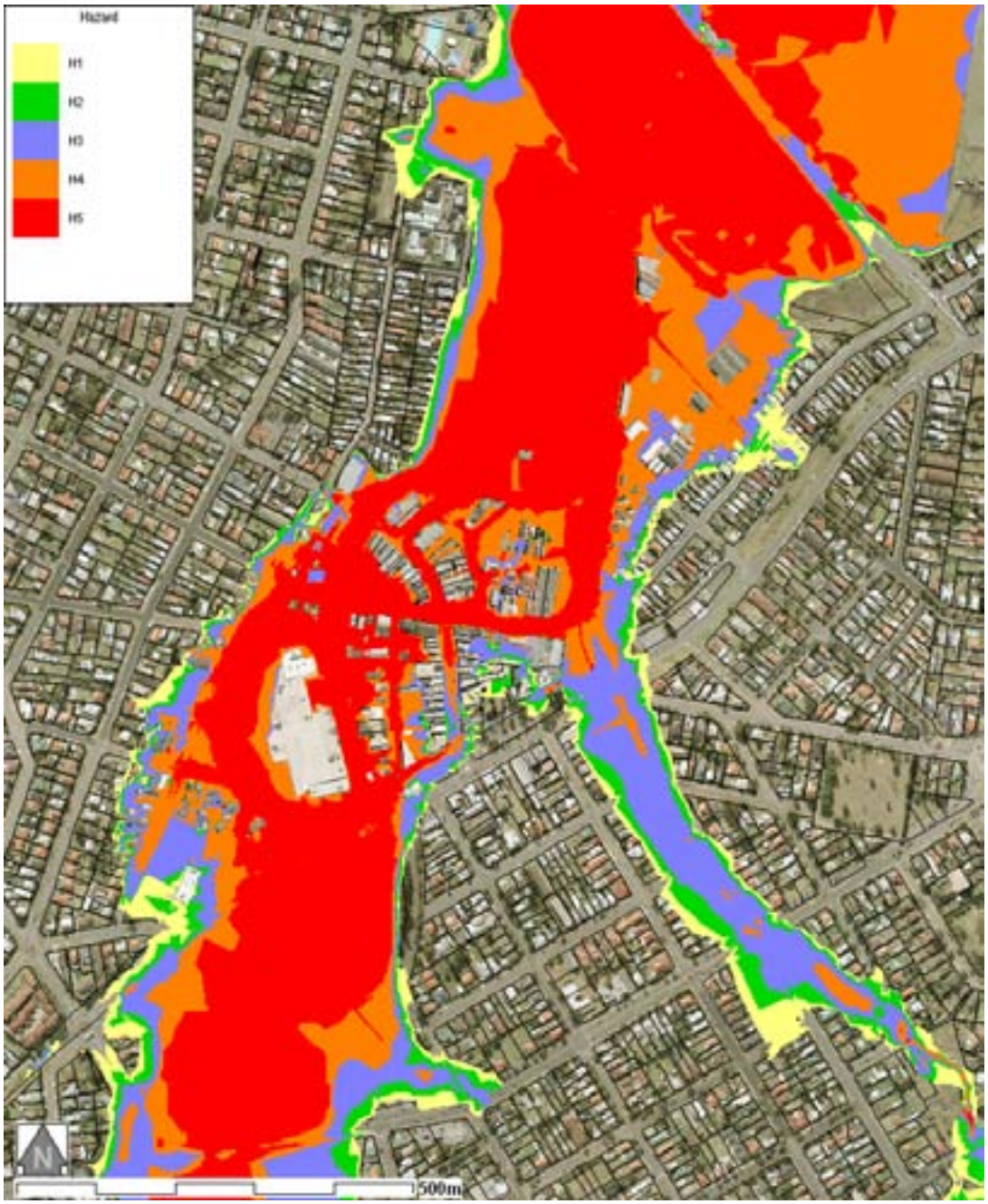


Figure 12 - Commercial Centre Peak Hazards - Probable Maximum Flood

3.1.4 Risk to Life Hazard Categories

Community Standards and Expectations

Loss of life is the worst possible consequence in the management of any hazard. Therefore the consideration and management of hazards that may result in loss of life become the highest priority for a community and society.

In relation to flood hazards, the NSW Government Floodplain Development Manual *(DIPNR, 2005)* states:

> *sG9.2 "(There is a) … need to develop additional management measures such as response modification measures to mitigate the danger to personal safety associated with overwhelming flood events."*
>
> *sA2.3 " The PMF or extreme event provides an upper limit of flooding and associated consequences…It is used for emergency response planning purposes to address the safety of people." AND "sK4.1 "Risk to life issues relate to the consequences of the full range of floods including the flood used to derive the FPL and rarer floods."*
>
> *The emphasis in floods larger than the flood used to derive the FPL is on danger to personal safety and associated emergency risk management." AND sK.1 "FPL's do not, however, ensure that development is located in areas where it will not have significant adverse impacts, nor do they address personal safety issues".*
>
> *sB3: The New South Wales floodplain risk management process … is a particular example of risk management and is in accordance with the guidelines set out in AS/NZ 4360:2004 ("Risk Management").*

The consideration and management of risk to life is required by the NSW Government Floodplain Development manual to cover all floods, including the worst case scenario *(the PMF)*, which is in turn in accordance with nationally recognised risk management practice published by Standards Australia. It is especially salient that risk to life cannot be managed solely at the probability of flooding where normal building controls, relating to the immersion of property, are considered but must extend to overwhelming *(albeit less likely)* floods.

NCC Risk to Life Hazard Categories

Newcastle DCP 2005 requires that the hydraulic behaviour thresholds (H_1- H_5) be applied to the PMF when considering the risk to life. This is essential in a flash flood scenario because the absence of effective warning time means that it is not possible to remove people from the threat to their lives by formal evacuation plans. There is simply no time to execute such plans.

The safety of individuals will rest on self directed evacuation. In those instances where people are likely to be trapped in a building surrounded by fast rising flood water which is too dangerous for wading, the self directed evacuation must be to an onsite refuge. The refuge should be safe and secure at the PMF to ensure that the risk to life is minimised in all possible floods.

Accordingly Newcastle DCP 2005 recognises 5 loss of life hazard categorises as set out in **Table 3.1.4**. These categories reflect an integrated consideration of:

- Size of flood;
- Effective warning time;
- Flood readiness;
- Rate of rise of flood waters
- Depth and velocity of flood waters *(i.e. H_1- h_5)*;
- Duration of flooding, evacuation problems;
- Effective flood access; and
- Type of development.

Table 3.1.4 - Loss of Life Hazard Categories (at the PMF) (source: Newcastle DCP 2005)

	HAZARD CLASSIFICATION				
HAZARD FACTOR	L1	L2	L3	L4	L5
Effective Warning	Y	N	N	N	N
Effective capacity to allow evacuation to flood free land	Y	Y	N	N	N
Rate of rise of flood waters	Slow	Flash	Flash	Flash	Flash
Duration of Flooding	Too long for refuge enclosed by floodwaters to be appropriate	Short enough for occupation during the entire flood to be appropriate	Short enough for occupation during the entire flood to be appropriate	Short enough for flood free refuge enclosed by floodwaters to be appropriate	Short enough for flood free refuge enclosed by floodwaters to be appropriate
Escape route	An obvious rising escape route to flood free land outside of the entire flood is available	An obvious rising escape route to flood free land outside of the entire flood is available	There is no obvious rising escape route to flood free land outside of the entire flood	There is no obvious rising escape route to flood free land outside of the entire flood	There is no obvious rising escape route to flood free land outside of the entire flood
Nature of enclosing floodwaters	Flood free land outside of the entire flood can be reached before the flooding affects the site itself	Reaching flood free land outside of the entire flood requires evacuation through enclosing floodwaters and these floodwaters are suitable for wading or heavy vehicles at all times	Enclosing floodwaters are suitable for wading and for medical emergency evacuation by wading or heavy vehicle at all times	Enclosing floodwaters are not suitable for wading or heavy vehicles and require heavy construction for structural stability of buildings (eg. steel frame and concrete)	No form of normal building construction would be feasible to ensure structural stability in enclosing floodwaters
Evacuation need	Required to flood free land outside of the entire flood	Required to flood free land outside of the entire flood	Not required	Required to suitable flood free refuge within the enclosed floodwaters	Normally not possible (therefore normally unsuitable for development)
Evacuation problems	Still need to ensure that any proposed development in these areas will not cause additional burden on emergency response services	Still need to ensure that any proposed development in these areas will not cause additional burden on emergency response services	Nil (for able-bodied adults)	Evacuation shall be self directed and fail safe	Enclosing floodwaters are so hazardous that evacuation by normal means to flood free land outside the entire flood would not be contemplated. The structural stability of an onsite refuge cannot be assured by normally available building types and therefore a refuge enclosed by floodwaters cannot (normally) be provided

The relationship between the loss of life hazard categories *(L_1-L_5)* and the hydraulic behaviour thresholds *(H_1-H_5)* is set out below.

				Hydraulic Behaviour Threshold				
				H1	H2	H3	H4	H5
Catchment Response Time	Riverine			L1				
	Flash	Escape Route to flood free land	available	L2		L4		L5
			not available	L3				

L_1 Riverine flooding where there is sufficient time to remove people from the risk to their lives by means of formal community evacuation plans. Not relevant to flash flooding scenarios such as the Wallsend Catchment.

L_2 Short duration flash flooding with no warning time in circumstances where there is an obvious escape route to flood free land with enclosing waters during the PMF which are suitable for wading or heavy vehicles i.e. hydraulic threshold does not exceed H_2. On site flood refuge not necessary and normal light frame residential building are appropriate.

L_3 Short duration flash flooding with no warning time and no obvious escape route to flood free land with enclosing waters during the PMF which are suitable for wading or heavy vehicles i.e. hydraulic threshold does not exceed H_2. On site flood refuge not necessary and normal light frame residential buildings and appropriate.

L_4 Short duration flash flooding with no warning time and enclosing waters during the PMF not suitable for wading or heavy vehicles i.e. hydraulic threshold exceeds H_2. On site refuge is necessary and if hydraulic threshold exceeds H_3, heavy frame construction or suitable structural reinforcement required.

L_5 Short duration flash flooding with no warning time and enclosing waters during the PMF have too much energy for normal heavy building construction and therefore it is generally not possible to construct a flood refuge i.e. hydraulic threshold is H_5. The risk to life is considered extreme and the site is unsuitable for habitation, either residential or short stay.

Figure 13 shows the application of the risk to life criteria *(L_1-L_5)* to the Wallsend Commercial Centre.

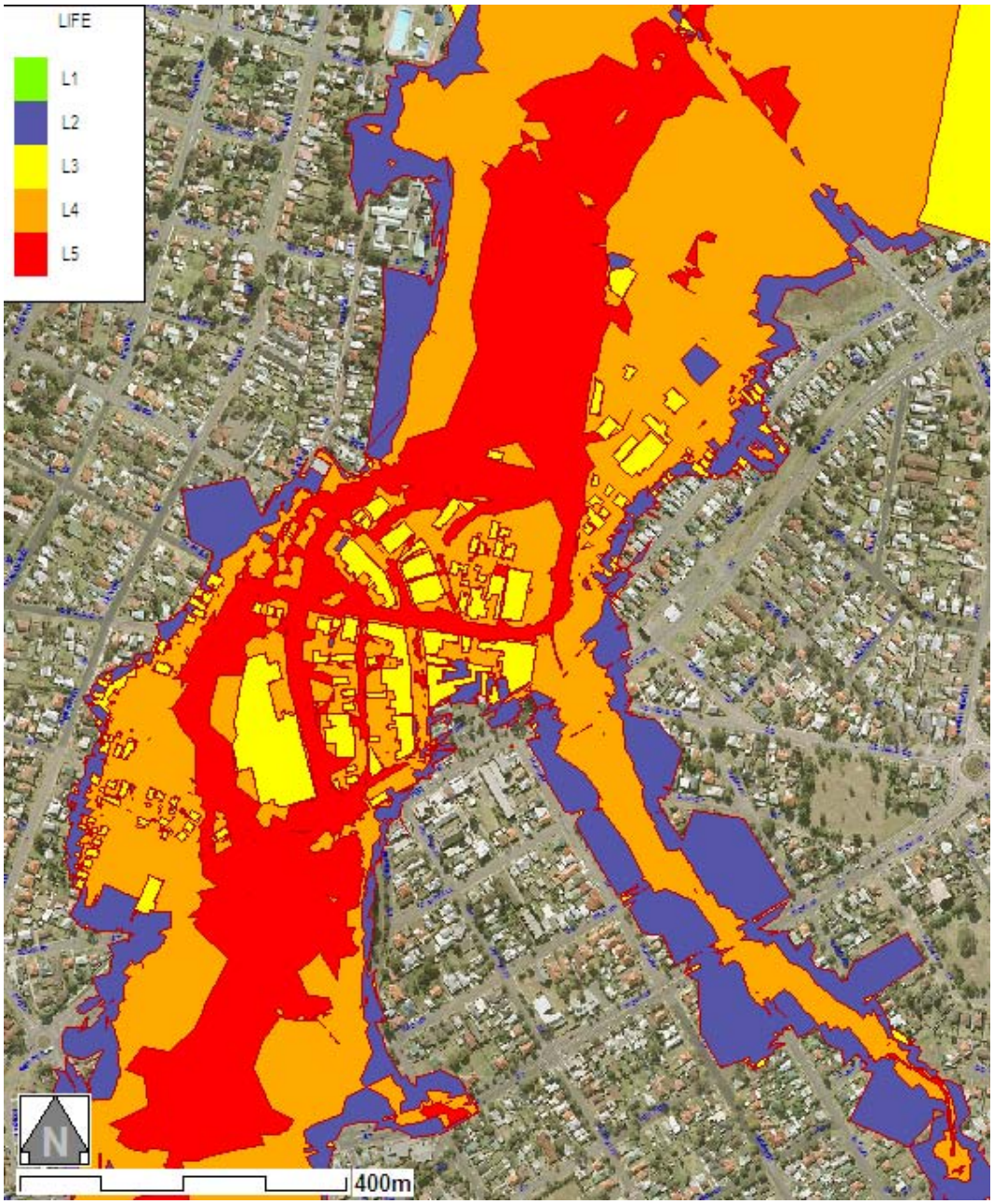


Figure 13 - Commercial Centre Risk to Life Criteria

Apart from the higher land on Cowper Street just east of Nelson Street, the greater majority of the Commercial Centre has been identified as having a very high to extreme risk to life category of L_4/L_5. This highlights the "bottleneck" which the Commercial Centre presents to large floods which are forced to flow through the central business district streetscape at dangerously high velocities and depths.

There are significant risks to life associated with people trapped in vehicles trying to escape the floodwaters either on foot or in vehicles, which may become unstable and swept away during flooding. These potential risks to life can occur in relatively frequent flash floods in the Wallsend Commercial Centre and clearly during larger floods, with the PMF presenting the upper limit. More information is found in s2.7 and s4.2.1, where for example, it is identified that people can be trapped in cars within 15 minutes in a 1 in 100 annual chance flash flood.

The hydraulic behaviour thresholds described in s 3.1.3 include a category "H_2" which is the limit where it is considered safe for wading by able-bodied adults. Pedestrians who are not able bodied adults, such as children or people with mobility limitations would be presented with higher potential risks.

3.1.5 Risk to Property Hazard Categories

Newcastle DCP 2005 requires that the risk to property hazards are based on the peak hydraulic behaviour thresholds *(H_1-H_5)* determined for the 1 in 100 annual chance flood. A flood planning level is adopted as the 1 in 100 annual chance flood level plus a freeboard which is uniformly set at 0.3 metres.

Five risks to property hazard categories *(P_1-P_5)* are defined by Newcastle DCP 2005. P_1-P_5 correlate directly with H_1-H_5 as follows:

- P_1 Parked or moving cars remain stable i.e. equivalent to areas of H_1 at the Flood Planning Event.
- P_2 Parked or moving heavy vehicles remain stable i.e. equivalent to areas of H_2 at the Flood Planning Event.
- P_3 Suitable for light construction *(eg. timber frame, masonry and brick veneer)* i.e. equivalent to areas of H_3 at the Flood Planning Event.
- P_4 Suitable for heavy construction *(eg. steel frame, reinforced concrete)* i.e. equivalent to areas of H_4 at the Flood Planning Event.
- P_5 Hydraulically unsuitable for normal building construction is equivalent to areas of H_5 at the Flood Planning Event.

The distribution of P_1-P_5 is identical to the related H_1-H_5 *(at the Flood Planning Event)* as shown in **Figure 10**.

3.2 Floodplain Hydraulic Categories

3.2.1 Definition of Floodway, Flood Storage and Flood Fringe

A crucial task is the strategic consideration and management of the potential cumulative impacts of gradual ongoing development over time. It is essential that these potential impacts be understood and managed across the whole floodplain in advance of future development.

The NSW Floodplain Development Manual (2005) requires that planning for future development be implemented by dividing the floodplain into three "hydraulic" categories: Floodway areas, Flood Storage areas and Flood Fringe areas. The Manual guides:

> *"At the outset … hydraulic and hazard categories are tools to assist in the preparation of an appropriate floodplain risk management plan (a strategic planning document). They are not to be used … in an adhoc analysis (that cannot take into account cumulative impacts) for the assessment of development proposals on an isolated or individual basis."*
>
> *"(Hydraulic categories are used for)…The division of floodprone land - for the full range of potential floods - that reflect the impact of development activity on flood behaviour."*
>
> *" This involves breaking the floodplain down into … areas with different hydraulic functions (which can vary between floods of different magnitudes). These are floodways for flow conveyance, flood storage for the temporary storage of flood waters…and the flood fringe … remaining…"*
>
> *"In determining appropriate hydraulic categories, it is important that the cumulative impact of progressive development be evaluated, particularly with respect to floodway and flood storage areas."*
>
> *"FLOODWAYS are those areas where a significant volume of water flows during floods and are often aligned with obvious natural channels. They are areas that, even if partially blocked, would cause a significant increase in flood levels and/or a significant redistribution of flood flow, which may in turn adversely affect other areas. It is essential that this be investigated across the full range of potential floods as the definition of the floodway is one of the most critical steps in the floodplain risk management process. They are often, but not necessarily areas with deeper flow or areas where higher velocities occur."*
>
> *"FLOOD STORAGE areas …. Are important for the temporary storage of flood waters … (and if) … completely (or) substantially (removed) or reduced by levees or landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased, (and / or) may cause a significant redistribution of flood flows."*
>
> *"FLOOD FRINGE – other."*
>
> *"It is impossible to provide explicitly quantitative criteria for defining floodways and flood storage areas … Areas … should be treated as contiguous entities, having regard for topography and location within the overall flood-prone area."*
>
> *"Case-by-case decision making cannot account for the cumulative impacts on flood behaviour and risks, caused by individual developments or works. This form of ad hoc assessment contravenes the principles of the manual."*

The key considerations when deciding the areas of floodway, flood storage and flood fringe hydraulic functions are therefore hydraulic characteristics and functions during floods and potential cumulative impacts of future development across the full range of floods up to the worst case scenario *(PMF)* - for the floodplain as a whole.

3.2.2 Wallsend Hydraulic Categories

Figure 14 shows the hydraulic categories for the Wallsend Commercial Centre. It is noted that there are predominantly two categories; Floodway and Flood Fringe because the hydraulic nature of flash floods in the catchment does not admit flood storage areas as explained below.

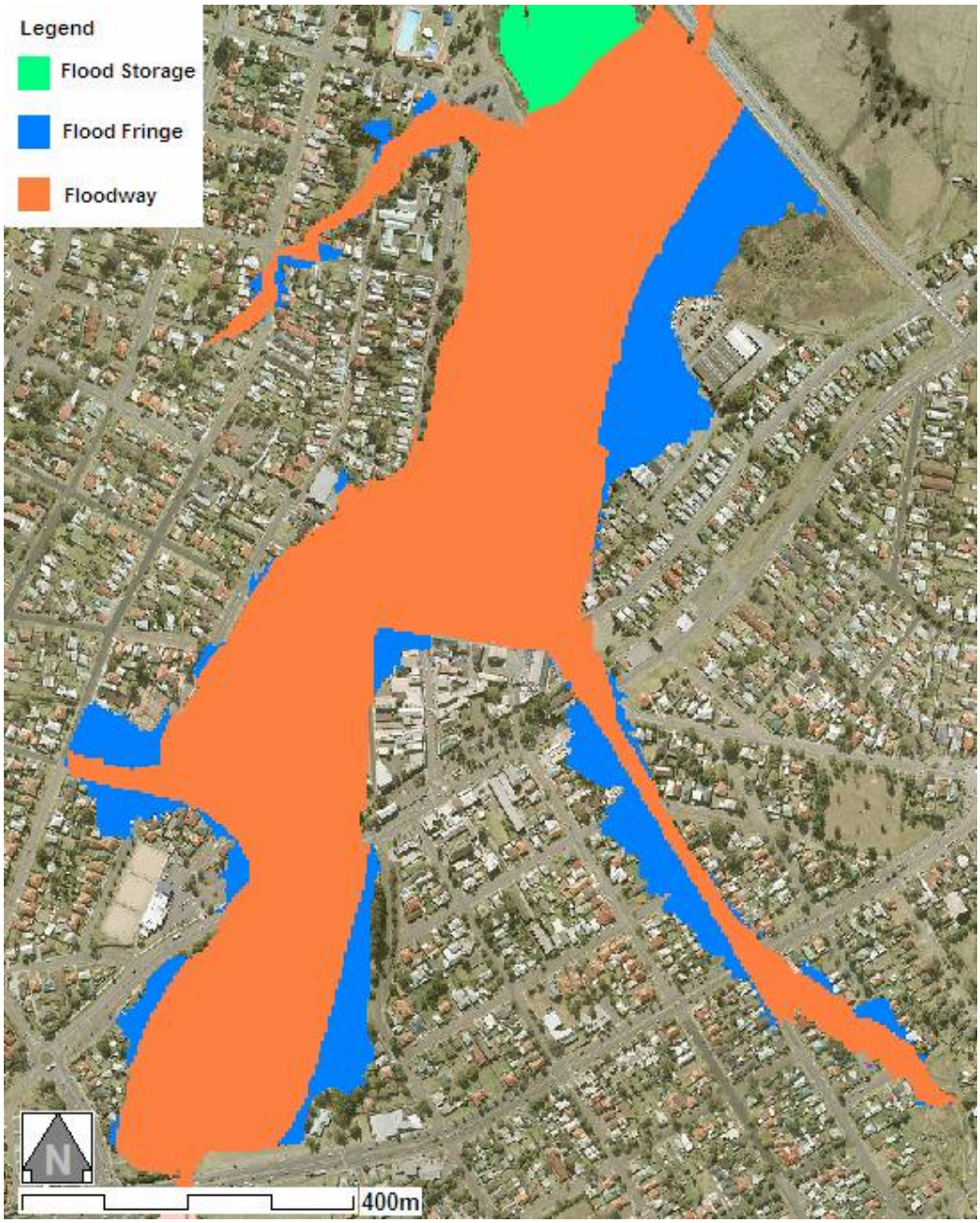


Figure 14 - Commercial Centre Hydraulic Categories

Flood Fringe

The outer edge of the flood fringe is, by definition, the limit of the PMF flood extent.

The inner extent of the Flood Fringe was determined by the flood model as the limit line for filling of the **entire** flood fringe which would not cause a significant impact on flood behaviour (*i.e. peak flood levels or flood hazards*). The **entire** flood fringe was effectively deleted from the model so that it was not available for flow conveyance or flood storage.

The increase in peak flood levels associated with the 1 in 100 annual chance flood is mostly zero with only a few isolated locations up to 0.1m.

Taking into account the negligible impact on the 1 in 100 annual chance flood and the extremely low probability occurrence of the PMF, it is considered that the impacts of filling/building within the Flood Fringe, identified on **Figure 14**, are acceptable.

Floodway

When criteria were examined which would identify potential flood storage areas, such as conditions where the velocity is less than 0.1m/sec in the 1 in 100 and 1 in 500 annual chance floods, they occurred inside the flood fringe area. However, the flood fringe was determined as the area where filling would have no effect. Consequently it was concluded that the Ironbark Creek floodplain does not possess any functional flood storage areas.

Therefore the area inside the limit line for the flood fringe is appropriately identified as floodway. This is considered to be consistent with the nature of floods in Ironbark Creek which rise quickly within a relatively steep and narrow floodplain with no opportunity for temporary storage of floodwater in off-channel storage areas. The flow is confined to the main stream and stream parallel overbank flow with significant velocities.

Increases in peak water levels at the 1 in 100 annual chance event are typically less than 50mm, which is considered acceptable.

4. DETAILED EXISTING HAZARD ANALYSES

This section examines the extent to which existing floodprone commercial and industrial buildings in the Wallsend Commercial Centre comply with the various risk to life and risk to property hazard criteria discussed previously.

Non compliance *(i.e. buildings are subjected to hydraulic hazards which exceed the safety thresholds designated in Newcastle DCP 2005)* identifies individual buildings or groups of buildings which have an unacceptable risk.

This risk needs to be addressed by floodplain risk management measures in the following sections.

This section, therefore, serves to identify all the properties in the Wallsend Commercial Centre which have an undesirable flood hazard and require specific attention in the floodplain risk management plan.

4.1 Risk to Life

The risk to life can be difficult for a community to accept because it relates to rare flood events of which there is no experience. As demonstrated previously, the risk to life in the Wallsend Commercial Centre is very real. The number of lives at risk can be measured in the thousands in a worst case scenario involving a severe flash flood occurring on a busy business day. Hence any disbelief towards the risk should not be allowed to deflect the Community from implementing appropriate mitigating measures.

4.1.1 Commercial / Industrial L_4-L_5/H_5

Commercial and industrial buildings which have a loss of life category of L_4 or L_5 and a hydraulic behaviour threshold of H_5 constitute an extreme risk to life and can be considered unsuitable as even short stay places of occupation. These buildings constitute the greatest need for risk management within the ambit of the floodplain management plan.

Figure 15 shows the location of all commercial and industrial buildings which are subject to L_5/H_5 hazard categories at the peak of the PMF. As noted previously, the buildings include the greater majority of the Commercial Centre and collectively represent the “bottleneck” in the Ironbark Creek floodplain. In total, 90 commercial and industrial premises are identified including the very large Wallsend Plaza shopping centre. This is the area of greatest potential loss of life in a large flood and is therefore the key focus area for the floodplain management plan. Options to manage this risk are discussed in **Section 7**.

Figure 15 - Commercial and Industrial Properties Subject to L_4-L_5/H_5 Criteria (shown in Green)

4.1.2 Commercial / Industrial L_4/H_4

Many of the commercial/residential buildings in the Commercial Centre are very old buildings. Consequently, from a structural integrity viewpoint, many of the buildings could be considered to be no stronger than a modern day, light frame residential building. As such, these buildings are likely to suffer severe structural damage and possibly collapse, when the adjacent flood waters have a hydraulic behaviour threshold of H_4. If buildings designated as L_4, in the PMF, could be subjected to a hydraulic hazard of H_4 during much more frequent floods, such as the FPE (1 in 100 annual chance event), they would have a much higher risk to life and would warrant a high priority in the implementation of the floodplain management plan.

The modelling indicates there is only a small area of H_4 hazard at the peak of the FPE (*1 in 100 chance*) along Council at the rear of the Nelson Street shops and a handful of these properties would be subjected to this hazard category.

4.2 Risk to Property

4.2.1 Car Parks – P_2

Newcastle DCP 2005 stipulates that areas with a property hazard P_2, at the peak of the FPE *(i.e. 1 in 100 annual chance flood)*, are unsuitable for use as public carparks. **Figure 16** shows the public car parking areas of the Commercial Centre which do not conform to the minimum safety thresholds of Newcastle DCP 2005.

Whilst the primary focus in this section is the potential for damage to private vehicles in a flash flood situation, there is also a collateral risk to life which extends beyond the 1 in 100 annual chance flood. Anyone attempting to move their vehicle from any of these car parks in the early stages of any flash flood would be risking their life. Many fatalities in the more common floods that have occurred around the State have been associated with people trapped in cars by fast rising and/or swiftly flowing waters.

Options to manage the risk to both life and property *(i.e. vehicles)* in car park areas subject to a property hazard of P_2 are discussed in **Section 7**.

Figure 16 - Areas of Carparks with P2 or Greater Hazard (1 in 100 Flood)

4.2.2 Vehicle Parking – P_3

The risk to property hazard P_3 identifies areas which would be unsuitable for the parking or driving of heavy vehicles in a flash flood situation. There are a number of industrial complexes backing onto the concrete channel along the east side of Federal Park where heavy vehicles are regularly parked in concentration, however only one small area at the end of John Street is subject to P_3 property hazard.

4.2.3 Destruction of Buildings – P_4 and P_5

Previous sections highlight that the larger floods *(i.e. between 1 in 500 year chance and PMF)* have sufficient power to cause so much structural damage to buildings in their path that significant numbers would be destroyed. In accordance with Council's property damage criteria residential buildings are likely to fail when the local hydraulic hazards equate to H_4/P_4 or higher for light frame structures and H_5/P_5 for heavy construction.

Analysis of the flood hazards within the Wallsend Commercial Centre indicates that 2 commercial/industrial buildings would likely be destroyed during a 1 in 500 chance flood and 143 buildings would similarly be affected in a PMF.

The prospect of large floods destroying buildings is often looked upon with scepticism by the general public because of their lack of experience of such events. However, in the last decade, the occurrence of large floods, associated with extensive building destruction, in Europe and USA has underscored how very real this risk is.

The reconstruction of New Orleans, in the aftermath of flooding caused by cyclone Katrina, is currently estimated to be of the order of $160 billion *(ICN, 2007)*. Extensive studies of the damage potential of large floods in the Hawkesbury Valley concluded that a repeat of the 1867 flood of record *(estimated to be a 1 in 250 annual chance flood)* would destroy up to 2000 homes. A PMF in the Hawkesbury could destroy up to 16,000 homes *(HNFMAC, 1997)*.

Hence there is no room for complacency in respect of the potential for high energy flash floods to destroy buildings in the Wallsend Commercial Centre.

The likely destruction of buildings in the Wallsend Commercial Centre, in floods greater than the 1 in 100 year annual chance *(eg. 1 in 500 annual chance flood and the PMF)* contributes significantly to the economic losses and the risk to life associated with these floods. The destruction of buildings and possible related loss of life would also be a key determinant in the scale of intangible damages such as community health impacts.

4.3 Review of Flood Planning Level (FPL)

4.3.1 Selection of Flood Planning Event (FPE)

Newcastle DCP 2005 currently adopts the 1 in 100 annual chance flood as the flood planning event *(FPE)* and the FPL as the peak of the FPE plus a free board of 0.3m.

The 1 in 100 annual chance flood is commonly regarded as an acceptable risk of above floor flooding and immersion damage when considered in the context of an average life time. The Manual *(DIPNR, 2005)* recommends that the 1 in 100 annual chance flood should be adopted in respect of any new development areas.

The FPE should be selected with a view to effectively managing personal safety in rare events i.e. floods rarer than the FPE *(DIPNR, 2005)*. As noted previously, the risk to life is considered to be the prime floodplain management issue in the Wallsend Commercial Centre because of its propensity for flash flooding. The selection of a FPE can help address this issue by establishing a minimum floor level which steers development away from relatively low lying floodprone lands which have the greater risk to life.

The Manual also indicates that the selection of FPE should take into account what are appropriate land uses in the context of the flood hazard associated with floods much higher than the FPE. It recommends that the selection of the FPE should curb the siting of new development in inappropriate areas and reduce the exposure of people to dangerous flood situations.

In relation to the high risk to life associated with the rarer floods in the Wallsend Commercial Centre, it is considered that the FPE should help to steer future redevelopment away from those areas of the floodplain which have a high risk to life category of L_4 and a hydraulic threshold criteria of H_4, at the peak of the PMF. These areas have been identified as having a high risk to life, after consideration of evacuation feasibility and the potential destructive power of floodwaters.

Figure 17 shows the extent of the 1 in 100 annual chance flood superimposed on boundary between the H_4 & H_5 zones *(PMF)*. It can be seen that the extent of the 1 in 100 annual chance flood is a reasonable approximation of the limit of the H_4 *(PMF)* area. Hence, it is considered that a FPE of no lower than the 1 in 100 annual chance flood is appropriate since it may assist in steering future development away from high hazard areas in the Commercial Centre.

The analysis of flood levels indicates that the floor levels of the older buildings imply a defacto flood standard which is of the order of a 1 in 10 to 1 in 20 annual chance. This is less than the 1 in 100 annual chance FPE. However, this lower historical standard has presided over inappropriate encroachment of buildings onto the floodplain in the Commercial Centre. With the hindsight of a full understanding of the flood hazards that are possible it is now appreciated that these encroachments are exposing people to an unacceptable risk to life during very large floods.

Hence, it can be argued that the FPE should be much higher than the historical 1 in 10 to 1 in 20 annual chance floods to prevent escalation of the number of people exposed to dangerous flood situations. In this regard, for the reasons outlined above, it is concluded that the 1 in 100 annual chance flood is an appropriate flood planning event for the Wallsend Commercial Centre.

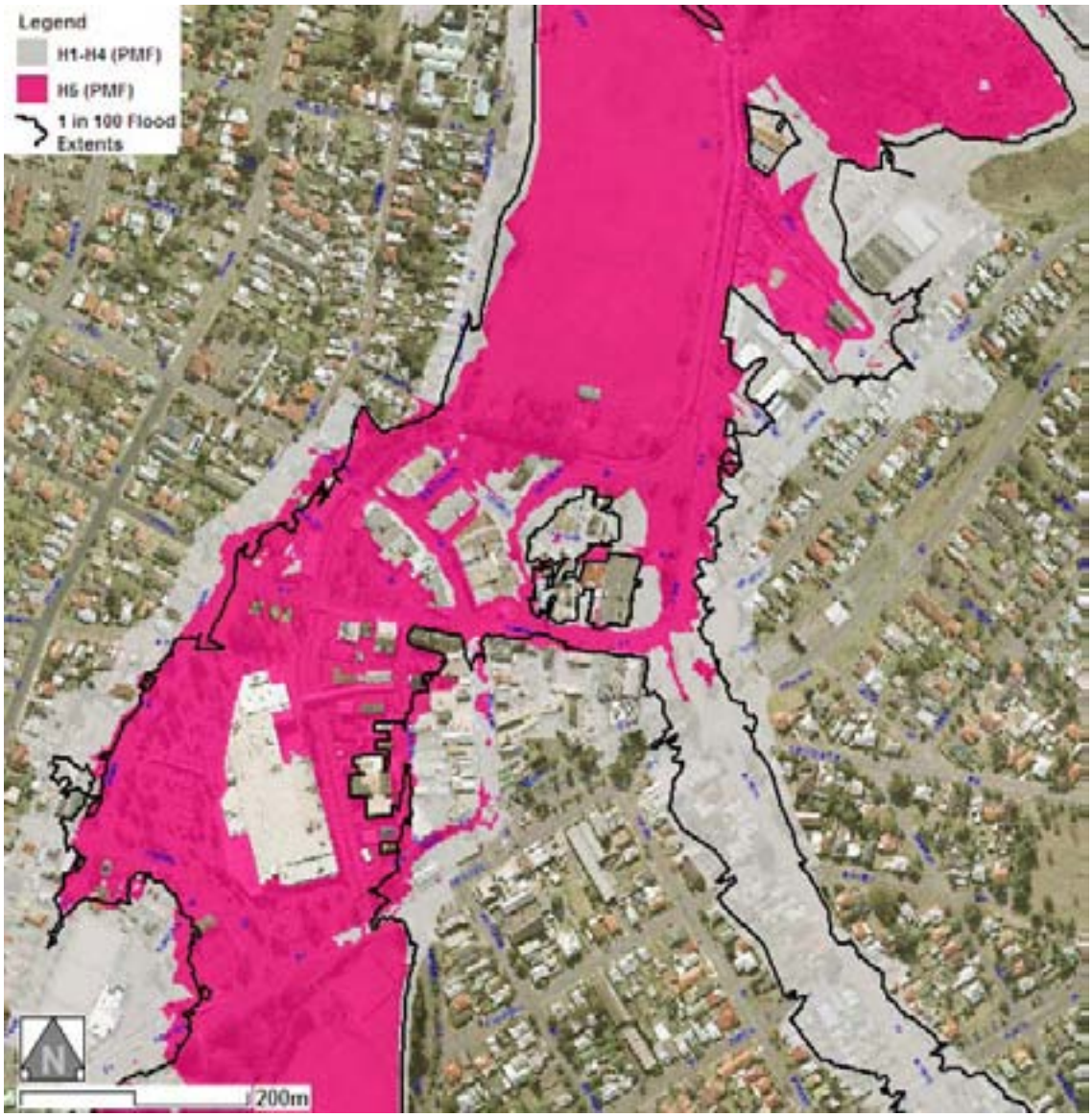


Figure 17 - Comparison of 1 in 100 Flood Extent with H_4-H_5 (PMF) Boundary

4.3.2 Social Issues

The Manual *(DIPNR, 2005)* indicates that there are a number of social issues that need to be considered when determining the FPE.

Non sterilisation of Land – the selection of a FPE should consider impact on the availability and demand for land. As the Wallsend Commercial Centre is already heavily urbanised, this is not an issue which affects greatly the selection of an FPE.

Optimal use of infrastructure –because the Wallsend Commercial Centre is heavily urbanised public infrastructure providing essential services needs to be protected to assist rapid recovery.

Current FPL- the community is familiar with the current FPL which was adopted by Newcastle City Council in 2004. There are considerable community awareness benefits in adhering to the current FPL.

Risk exposure – because of its propensity for flash floods, the Wallsend Commercial Centre has a high risk to life potential and it is appropriate to keep the FPE at the peak of the 1 in 100 annual chance flood.

As noted previously, the 1 in 100 annual chance flood defines the major floodplain and past encroachments into this area have created risk to life situations. Hence any lowering of the FPE *(and FPL)* cannot be justified on the grounds of risk to life.

Social equity – Apart from the Commercial Centre, there is a significant area of riparian parks and recreation facilities located along Ironbark Creek *(and its tributaries)* within the flood extent of the1 in 100 annual chance flood. This riparian corridor is valued highly by the community. It is important that this area be preserved as an open space recreation and ecological corridor as well as an essential flood conveyance area.

4.3.3 Freeboard

In relation to freeboard, the NSW Government Floodplain Development Manual *(DIPNR, 2005)* states:

> *sK5 "The purpose of freeboard is to provide reasonable certainty that the reduced risk exposure provided by selection of a particular flood as the basis of a FPL is actually provided."*

The manual then identifies an number of factors that can affect the selection of a freeboard including:

- *Uncertainties in flood estimates* – this has been minimised for Wallsend by the use of a calibrated and verified two dimensional hydrodynamic model.
- *Localised differences across the floodplain* – this is addressed through the use of a two dimensional model.
- *The effects of wave action* – in Wallsend there is insufficient fetch for any wind induced wave action and hydraulic conditions would be too dangerous for any safe boating activity.
- *The effects of climate change* – this factor has been addressed through modelling of increased tailwater levels and is discussed later in the report.

- *The cumulative effect of infill development* – this has been addressed through the modelling of floodplain constriction and is discussed below.

An additional factor, not mentioned in the manual, that impacts the selection of a freeboard allowance in urban areas is that of culvert, bridge and flowpath blockages caused by natural and urban debris such as trees, 'wheelie' bins, cars, containers, etc.

The model was used to test the sensitivity of flood behaviour to likely representative blockages of the various bridge openings together with a 'car jamb' at the northern end of the Plaza shopping centre. It is unlikely that all these openings would become partially blocked at the same time, however the results can be used to assess the incremental impacts of each blockage progressing upstream to check whether the freeboard allowance would be sufficient to cover the increase.

Table 4.3.3 – Impacts of Blockages on Flood Levels

Blockage	Incremental Increase	Comment
Boscawen St	0.25 m	
Nelson St	0.08 m	Less blockage than Boscawen St.
Tyrrell St	0.03 m	Lies in the backwater effect of Nelson St. shops and flow can bypass the opening
Shopping Centre	0.58 m	A significant impact on the Plaza carpark diminishing to 0.25m upstream of Cowper St..
Cowper St	0.25 m	Very localised effect immediately upstream

Apart from the shopping centre blockage which essentially only affects the carpark and the shopping centre building, the impacts of each blockage can be accommodated by the defined freeboard allowance included in the flood planning level and no adjustment is considered necessary for the Commercial Centre.

4.4 Cumulative Flood Risks

The Floodplain Development Manual *(DIPNR, 2005)* places considerable importance on establishing development controls in a floodplain which take into account the cumulative impact of all development *(existing and future)* on flood behaviour. This is to avoid future development adversely affecting the flood hazards on existing development.

Cumulative flood impacts can arise from filling or constriction of the floodplain or increased rates of rainfall runoff due to decreasing catchment permeability *(i.e. increased roof and paved surfaces)*.

4.4.1 Floodplain Filling and Constriction

In a previous section (s3.2.2), the flood model was used to establish areas of floodway and flood fringe. The flood fringe was established by determining a limit line for maximum filling of the floodplain which would not have a significant impact on flood behaviour.

Effectively, any filling or constriction of the area identified as flood fringe in **Figure 14** can be carried out without any significant cumulative impact on flood behaviour. Newcastle DCP 2005 has strict provisions for the control of development within the areas identified as floodway in **Figure 14** to ensure that there are no adverse impacts on flood conveyance.

5. COMMUNITY COST OF FLOODS

5.1 Introduction

Floods impact upon a community in many ways including loss of life, health problems, residential and commercial damage and loss of services. These economic and social factors need to be both identified and where possible quantified so that the impact of flooding is fully appreciated.

Flood damages can be defined as either *tangible* or *intangible*. Tangible damages are those losses that can be readily defined in financial terms such as damage or destruction of property, loss of wages due to post-flood clean-up etc. Intangible damages arise from the social and environmental effects caused by flooding and evacuation such as death, emotional stress and loss of economic confidence.

Tangible damages can be further subdivided into *direct* and *indirect* damages. Direct tangible damages result from the actions of floodwaters, inundation and flow, upon property and structures. Indirect damages arise from the disruptions to physical and economic activities caused by flooding.

The indirect damages arise from the need to provide alternative accommodation while dwellings are reconstructed, for repairs to commercial properties and to account for loss of business, for disruption to road and rail traffic and for loss of utilities' revenue. These indirect impacts from flooding can last from several days of traffic disruption to months for house reconstruction, and full recovery of industrial and commercial business operations.

Utility damages escalate in the more extreme flood events with further damage to key water, sewerage, electricity, telephone and gas assets. These increasing impacts result in indirect utility damages becoming a more substantial proportion of the total as people outside the floodplain become affected and the delays in service restoration are extended.

Figure 18 shows the types of flood damage and their interrelationships.

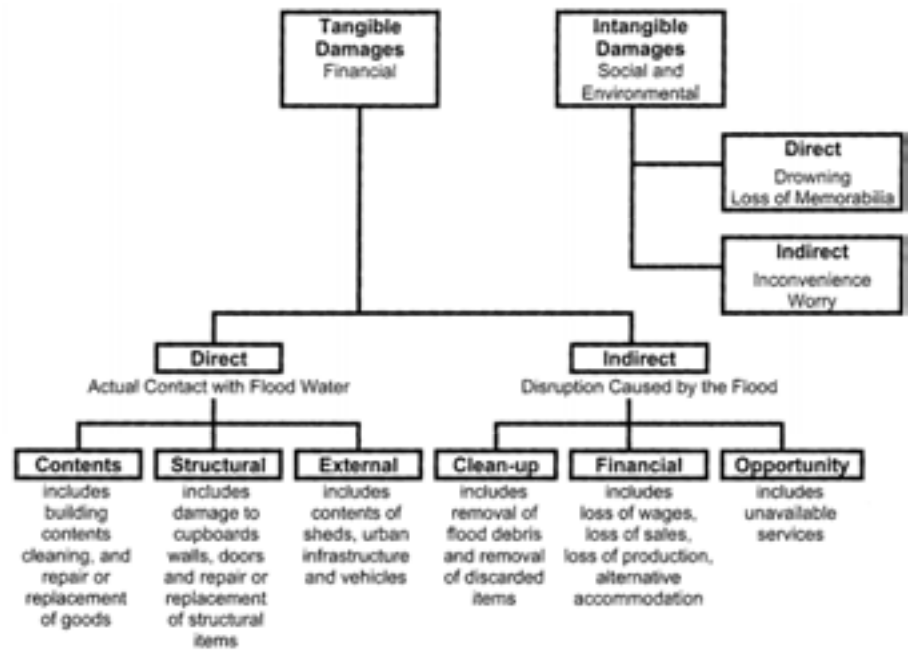


Figure 18 - Structure of Flood Damages (DIPNR 2005)

5.2 Flood Affected Properties

Table 5.2 shows the total number of commercial/industrial properties and buildings that are inundated at the various flood frequencies.

Above floor flooding is based on a survey of floor levels carried out by Council in 2000. Vacant flood affected properties are not included **Table 5.2**.

Table 5.2 - Flood Affected Properties Containing Buildings

Annual Chance Flood	Commercial/Industrial Properties		
	Floodprone properties	Properties with above floor flooding	Proportion of floodprone properties
1 in 5	56	14	9%
1 in 10	65	25	32%
1 in 20	69	37	43%
1 in 100	108	51	51%
1 in 500	115	56	52%
PMF	169	137	77%

5.3 Tangible Flood Damages

5.3.1 Methodology

Tangible damages can be calculated for each design flood *(i.e. 5yr, 10yr, 20yr, 100yr, 500yr and PMF)* based on property value and the peak depth of overfloor flooding associated with each flood at each property. The individual property damages are tallied to produce an estimated total tangible flood damage for each design flood.

Damage Curves

Damages associated with industrial/commercial properties were determined on a per square metre basis using damage curves developed by Water Studies *(1992)*. These damage curves do not take into account the value of the building if it is destroyed by an extreme flood.

In-Tangible Damages

In-Tangible damages generally related to clean-up, health and lost opportunities are usually added as a factor related to the calculated tangible damages. Extensive flood damage studies carried out for the Warragamba Dam IDC*(1992)* identified a range of 20% to 30% as an additional factor for intangible damages in the commercial/industrial sector.

Average Annual Damage and Present Value

The risk-damage relationship represented by the flood damages determined for each design flood can be expressed as an average annual damage *(AAD)*. The AAD is akin to summing up the damages from all floods occurring over a very long term and averaging them out on a yearly basis.

The AAD was discounted over a period of 50 years, at a discount rate of 7%, to determine the present value of the flood damages. The 'present value' represents the value of saving and investing the AAD over a planning period of 50 years. Sensitivity to discount rate was also included in line with Treasury guidelines at +/- 4%.

Destruction of Buildings

Section 4.2.3 points out that the larger flash floods of Ironbark Creek, in excess of the 1 in 100 annual chance flood, possess sufficient power, to destroy some of the residential and, to a lesser extent the commercial/industrial buildings in their path. The potential number of buildings destroyed, escalates rapidly towards the PMF.

Consequently the damage calculations for these rarer floods should include the value of buildings that are likely to be destroyed in addition to contents damage and indirect costs. The value of potentially destroyed buildings was incorporated into the damage estimates using typical industrial/commercial and residential building values supplied by Council. Because the number of buildings that will be destroyed in any one flood cannot be predicted with absolute certainty, the number of buildings destroyed was expressed as a range, based on Council's P_4 and P_5 criteria (**Section 4.2.3**) and sensitivity settings of 100% and 50% of the maximum potential.

Extensive flood damage studies carried out for the Warragamba Dam IDC *(1992)* adopted the 50% sensitivity level as an appropriate contribution of building failure to the overall determination of tangible flood damages.

Table 5.3.1 - Commercial & Industrial Economic Damage Profile - Wallsend Commercial Centre

	Properties Affected	Base Tangible Damages	Buildings Destroyed	Building Damages	In-Tangible Damages#	Total Damages
1 in 5 chance	5	$0.153M	-	-	$0.013M - $0.046M	$0.153M
1 in 10 chance	21	$0.532M	-	-	$0.107 - $0.160M	$0.532M
1 in 20 chance	30	$0.922M	-	-	$0.184M - $0.277M	$0.922M
1 in 100 chance	55	$2.360M	-	-	$0.472M - $0.708M	$2.360M
1 in 500 chance	60	$6.110M	1-2	$3.055M – $6.110M	$1.222M - $1.833M	$6.216M- $6.321M
PMF	139	$23.722M	67-135	$11.861M – $23.723M	$4.745M – $7.117M	$35.496M – $47.445M
Average annual damage						$258,383 - $279915
PV @7% discount rate						$3.566M - $3.863M
PV @ 4%						$5.6M - $6.0M
PV @ 10%						$2.6M - $2.8M

* Expressed as a range of 50-100% of the maximum potential
\# Expressed as 20% to 30% of tangible damages (Smith 1992)

5.3.2 Discussion of Tangible Damages

Tangible flood damages increase in moderate increments through the more frequent floods, but increase exponentially with each flood above the 1 in 20.

Flood damages for industrial/commercial properties in the Commercial Centre almost triple between the 1 in 100 annual chance flood and the 1 in 500. This reflects the increased depth of flooding in the rarer floods.

The economic impact of building failure begins to have an impact at the 1 in 500 annual chance flood and becomes a major component of the damages during the very rare floods.

In an extreme flood, the total tangible damages for commercial and industrial properties within the Commercial Centre are estimated to be in the range $35 million - $48 million depending upon the extent to which the potential for building failure is fully realised.

5.4 Intangible Damages

Intangible damages can be sub-divided into two types -direct and indirect. *Direct* damages include loss of life and the community health consequences of the trauma and anxiety felt by flood victims, and damages, to items of environmental, cultural or heritage, significance. *Indirect* damages include, inconvenience, disruption to essential services, loss of business confidence, opportunity costs etc.

Whilst community health impacts are not normally associated with commercial and industrial properties, they are considered to have some relevancy to small family owned businesses. These health impacts can be undervalued or ignored in assessments of flood damages because of the tendency to regard them as intangible. Australian research over the past 15 years indicates that the real cost of the flood related health problems of flood affected residents is at least equal to (and probably more than) the combined direct and indirect tangible damage associated with their dwellings.

5.5 Public Assets at Risk

Public assets relates to those facilities necessary for the continued functioning of the wider community that is reliant on them, whether or not the people in those communities reside in the flood affected catchment, and independently of ownership *(for example, ownership may be Government, Government Agency or Corporation, Public Company or privately owned)*.

The following public assets have been identified at risk, particularly from the more severe flood events:

- Roads in high velocity flood areas *(becoming unserviceable from surface scour or structural failure)*;
- Bridges *(becoming unserviceable from surface scour or structural failure)*;
- Water supply and sewer reticulation *(creek bed scour or debris loads may cause failure where mains cross bridges (which may collapse)* or become exposed, or are already aerial. There is no Sewerage Treatment Plant directly affected;
- Energy Supply – Gas and Electricity *(same as Water Supply, but in addition, scour and debris forces in high velocity areas has the potential to collapse power poles)*;
- Communications *(eg phone and internet)* where the infrastructure is land based – the same risks as Energy Supply;
- Health facilities – in the Wallsend Commercial Centre there are doctor's surgeries and other practitioner operated health facilities that would be severely damaged if not destroyed. Unless there is offsite backup of important medical and related information, irreplaceable records will be lost;
- Essential Retail – in the Wallsend Commercial Centre the large Wallsend Plaza shopping centre has essential retail facilities such as food and to a lesser degree clothing, which are also in smaller establishments in the remainder of the Wallsend Commercial Centre;
- Wallsend Library – this is a new Council facility that has been specifically designed for the flood environment. It has a refuge for people in severe and extreme events. Although the library collection is below the PMF *(and above the 1 in 100 annual chance event)* and there is some risk that the collection would be destroyed, the collection has however been managed to have no items of archival importance so that this risk is acceptable.

Severe flash floods have the potential to critically disrupt public assets to the extent that Wallsend's survival would be in question. A post disaster recovery plan therefore needs to be developed and written into the (LEMC led) Local Flood Plan.

6. COMMUNITY CONSULTATION

6.1 Consultation Process

The NSW Floodplain Development Manual (DIPNR, 2005) emphasises the need for inclusive community consultation during the development of a Floodplain Risk Management Plan. Consultation applicable to this Plan was undertaken in conjunction with the full Ironbark Creek Study (*March 2007 in draft*). The outcomes reported here are derived from that consultation process.

Following a recommendation of the Newcastle Flood Risk Management Committee, on 26 September 2006, Council resolved to place Draft Options for the Wallsend Elermore Vale Ranking Park Floodplain Risk Management Plan on exhibition. The public report to Council contained key exhibition and consultation background. (**See Appendix C**)

A communication strategy and process was developed in close collaboration with Council's Communications Group fulfilling the objectives of the NSW Floodplain Development Manual (*DIPNR, 2005*). The strategy was aimed at a genuine engagement of the community and affected parties with multiple means of notification and awareness. The use of highly visual flood mapping displays *(using WaterRIDE™ software)* was planned to give every opportunity for the community to understand the nature of the flood risks and the draft options.

Implementation of the communication strategy was comprehensive. The elements of the implementation process were:

- Prior notification of key stakeholders that the exhibition and consultation was about to be publicly advertised together with invitations to special meetings in the early phases.
- Public Notification (Newspaper)
- Lord Mayoral article in a local newspaper
- Media interviews
- A brochure outlining the draft options posted to all "specially affected" properties.
- Two public information meetings – one during the day and one in the evening
- Presentations to Council's community forums
- Distribution of Exhibition information bundles and response form in Council's administration centre and all libraries in Newcastle's Local Government Area.
- Electronic access to the information bundle and response form on Council's web site.
- Co-attendance by Council's legal officer at selected key stakeholder meetings where legal issues may arise.
- If needed, the opportunity for continuing dialogue was permitted after the formal exhibition period closed.

6.2 Community Feedback

The community and stakeholder feedback reflected widespread experience of flooding in the catchment and a general acceptance that the full range of floods, which go beyond past experiences, need to be well managed.

In overview, the recorded community and stakeholder responses were found to:

Confirm the reality of flash flooding in the catchment:

There were many vivid accounts of flooding and the personal distress caused. Very rapid rises of flood waters were reported, for example water rising 15 feet (about 5 metres) in a creek in 20 minutes;

Highlight the need for education and awareness coupled with improved warning:

Great concern was expressed for people new to the area who seemed to not realise or disregard the hazards associated with flash flooding when told by those who have experienced it. Concern for the safety of significant numbers of elderly who come to the Wallsend Commercial Centre (*for example to visit healthcare facilities*) was expressed, coupled with an expressed need for adequate warning;

Show a strong demand for creeks, channels, bridges and culverts to be regularly cleared of vegetation and debris:

There was vigorous demand expressed for creeks, channels bridges and culverts to be cleared of all obstructions. Some people felt that this would stop the flooding;

Show a strong demand for works that would stop the flooding:

Typically larger concrete lined channels or large “holding dams” in parks were called for. Some advocated measures to increase absorption or measures to “slow the water down”;

Be critical of past planning decisions:

There was criticism of past planning decisions. It was felt that too much development in the catchment had been permitted, and was continuing to be permitted. This was considered by some to be the root cause of the flooding. Development approval in susceptible flood affected areas was criticised;

Want future planning not to repeat the mistakes of the past:

It was indefensible to some that flooding was well known historically (*even in the 1880's*) and yet development in susceptible areas (*such as Nelson Street*) continued. Mistakes such as this must not be permitted to continue;

Express concern that the time of the decision making and the implementation process not jeopardise property values:

There was concern that as the research revealing the true nature of the flood risk and hazards becomes known over time, property values would fall;

Recognise the need to manage risks to life as well as property:

When computer flood mapping showing the potential for loss of life was shown (*for example in the Wallsend Plaza car park*), there was an openness displayed to accept that this will happen some time in the future, and it is a significant risk. "Rezoning" to reclaim open space for an improved passage of large volumes of flood waters and so reduce very severe risks to life in nearby occupied commercial areas was supported;

Offer general support for the scope of draft options exhibited:

Some offered general support that the draft options were needed. Others offered support for specific draft options.

Not offer any comments that would require the withdrawal or major modification to any of the draft options.

Although it is true that many views had a different emphasis to the overall mix of draft options exhibited, and some saw some difficulties that would need to be overcome, there was no option that was opposed.

6.3 Common Misconceptions

Like past generations, the present community will first attempt to understand the nature and implications of flooding by their direct experience of flooding *(or absence of experience)*. Understandably this may lead to incorrect conclusions by some in the community since the fuller understanding of flooding revealed by scientifically based assessments has not been accounted for.

This consultation and exhibition did reveal some misconceptions – which should not be taken as any criticism of the community who contributed. The presentation and discussion of the more common of these misconceptions in this section will positively serve to inform the preparation and implementation of continuing Flood Education programs.

Misconception: Cleaning the creeks will stop the flooding

The creeks and drains are only a very small part of the original floodplain. Major overbank floods require the full floodplain width to convey the flood waters irrespective of whether the creeks are concrete lined, cleaned or not. There are still reasons to maintain the intended water way areas of constructed creeks, drains, bridges and culverts, but the community needs to understand the more serious floods will still overwhelm these drainage capacities.

Misconception: Development has caused all the flooding

It is true that building smooth (*concrete lined or constantly cleared*) creeks and drains, straightening meandering creeks, removing trees and replacing them with roofs and roads and filling natural flood storages such as wetlands increases runoff and speed up the rise and passage of floodwaters, unless compensating measures such as On Site Retention are implemented.

The effects of past development on runoff can be very pronounced during and after the more frequent rainfalls which occur many times a year. The effects can be pronounced in the more common floods that can occur every decade or so. The community is familiar with these events and, as identified previously, long term residents have noted that the rate of rise of floodwater in the creek from shallow flow to a raging torrent running at bank full, is quicker than it used to be.

This first hand knowledge, however, can lead to an incorrect perception that development causes floods, and therefore if there was no development there would be no flooding.

It is important to understand that in the natural scheme of things, the full width of the natural floodplain has always been required to discharge the larger floods that occur every 20 – 50 years or the major floods which can occur more seldomly. The natural floodplain existed before any development, which is evidenced by the topography of the catchment and early aerial photos. The flood record illustrates that there was significant flooding in the Wallsend Commercial Centre in the late 1880's and early 1900's **before** any significant developed of the catchment.

The community needs to be aware that flooding is a natural part of the environment which, although modified by human activity, will always be a risk.

Misconception: The Flooding can be confined

This can be expressed as "bigger drains" or "hold the water back" or some combination. The desirability of this approach is understandable. If it were possible to confine all floods to lands where there was little threat to people or property there would be no need to respond to any flood, and development could continue uninhibited.

The flash flooding in the Wallsend catchment is so large, however, that it would not be socially or economically feasible to either: slow the water down by absorption, water tanks, or large holding dams in parks OR force the waters to stay "in the drains" by building larger stormwater channels and drains. To have any significant impact on large floods, the drains would have to be on a scale commensurate with the natural floodplain.

This is especially true for the extreme floods including the worst case scenario flood. For instance, the present concrete lined storm water channel passing next to Wallsend Plaza and continuing next to Federal Park would need to be widened from the present 17metres to 120 metres wide, with 1metre high above ground containment walls, to prevent the PMF from raging through the streets of the Commercial Centre.

Misconception: Elermore Vale has a detention basin

In the early 1990's it became known that Council was considering the construction of large excavated detention basins in the Wallsend catchment, including at Elermore Vale upstream of Cardiff Rd *(known locally as "Chinaman's Gardens")*. Later investigations showed these envisaged basins were in general not feasible because they would not have much buffering effect on very large floods *(especially floods that pose a large risk to life)*, because of the large cost, and social disruption. The very large floods would simply overwhelm the basin with very little change in flood peak levels or on the time of passage.

One community response indicated a misconception that a formal *(enlarged)* detention basin already exists upstream of Cardiff Rd. This is not the case, although the flood storage effects of the existing basin like area in this location have been taken into account in the flood modelling supporting this study.

6.4 Scope of Practical Measures

Practical measures need to address the risks to life and property across the full range of floods, including the worst case scenarios, as well as the effects of future development. At the same time, practical measures need to be socially and economically achievable.

This means, for example, that the following potential management measures are not really practicable, even though they may be desirable from some view points:

- Control the flooding by removing it from areas already developed; and
- Stop all future development / re-development.

Practical measures are based on living with the floods. The emphasis is on recognising there is a history of development which is incompatible with the risks unless the development is modified, and ensuring future planning does not repeat mistakes of the past. Inevitability there will be some compromises.

Practical measures will still include some large scale, difficult and sometimes controversial measures because the full range of floods needs to be properly managed. Continued occupation of the Wallsend Commercial Centre between Cowper Street and Federal Park, is dependent on the application of practical measures in a reasonable timeframe. A period of twenty years is suggested because during that time there is a small but significant chance of an extreme event happening.

6.5 Public Exhibition of Draft Wallsend Commercial Centre Floodplain Risk Management Study and Plan

On 7 April 2009 Council unanimously resolved to place the Draft Floodplain Risk Management Study and Draft Floodplain Risk Management Plan for the Wallsend Commercial Centre on public exhibition for a period of nine weeks and that the results of the exhibition be considered in the finalisation of the Study and Plan to be presented to Council for adoption.

The Draft plan was publicly exhibited for an extended period of nine weeks, and additionally key stakeholders were provided with presentations. Council's Wallsend Town Centre Committee was briefed on the draft Plan just prior to the start of the exhibition. A breakfast was held at the Wallsend Diggers Club on 6 May 2009 for business people and property owners in the Wallsend Commercial Centre where the Draft Plan was presented and discussion invited. Representatives of the Wallsend Town Centre Committee also attended two meetings of the Newcastle Floodplain Risk Management Committee where there was opportunity to listen to and interact with Council's specialist consultant who assisted in the preparation of the Plan.

The results of the exhibition are listed on the following page.

DRAFT WALLSEND COMMERCIAL CENTRE FLOODPLAIN RISK MANAGEMENT PLAN – SUBMISSIONS AND RESPONSES SUMMARY

	POINTS RAISED	NCC PROPOSED ACTION
Wallsend Town Committee	• Importance of business and community partnerships • Support for a complete flood emergency plan which Committee is implementing already • Wallsend Town Committee (WTC) and the Wallsend Emergency Network (WEN) Committee have not been sufficiently recognised as key stakeholders. • Importance of local representation (WTC and WEN) on Task Force	• Elaborate further in the report on consultation process undertaken to date and emphasise importance of consulting and involving community
Hunter Water Corporation	• Discussion on Emergency planning should also include risks to life associated with vehicles, pedestrians and mobility limitations. • HWC will participate within strategy to determine optimum community outcome to manage the flood risk, including providing more detailed assessment of HWC owned and maintained channels and pipes. • Does NCC have any preferred management strategies for ongoing ownership/operation and maintenance of new channels? • Concern that Plan focuses on PMF without considering the likelihood/probability of occurrence. Should consider impacts of nominated works on lower frequency rain events.	• Include a paragraph in the report on risks to life associated with vehicles, pedestrians and mobility limitations • Stage Two of the City-wide Floodplain Risk Management Plan will include modelling involving lower frequency events. However, the NSW State Government requires that the Plan focus on the PMF. • Benefits of works proposed in the Wallsend Commercial Centre Plan will be reported as part of the Stage 2 development of the City Wide Floodplain Risk Management Plan.
Community Resident 1	• Concern about creating refuges – potential for people to become trapped – and constructing an elevated walkway from Wallsend Plaza – should not be ratepayer funds • Alternative is to raise creek sides by half a metre to increase evacuation time plus install permanently fixed loud speaker	• No change to Plan proposed.

Community Resident 2	• Alternative Plan proposed to create a bypass tunnel starting at Wal Herd Park progressing under Cowper Street, along Dan Rees and Kemp Streets and exiting at Federal Park plus works to increase flow capacity under Minmi Road.	• No change to Plan proposed.
Community Resident 3	• Concern about veracity of data collected and modelling undertaken for the catchment. Theories provided on what actually occurs based on previous events. • Alternative plan based on warning system; increased maintenance (cleanup of the creek; cleaning drains); increasing flow across Minmi Road and Ironbark Creek bridge; increasing height of canal by up to 2 metres; flood funnel and protective wall for Cowper Street Bridge and the use of a 'Dutch Dam' to divert water over bridges.	• No change to Plan proposed.

6.6 Informing the Community of Outcomes

In addition to making this Study and Plan publicly available, briefing sessions explaining how the community responses have been considered and what is planned for the future need to be held after Council's adoption of the Study and Plan.

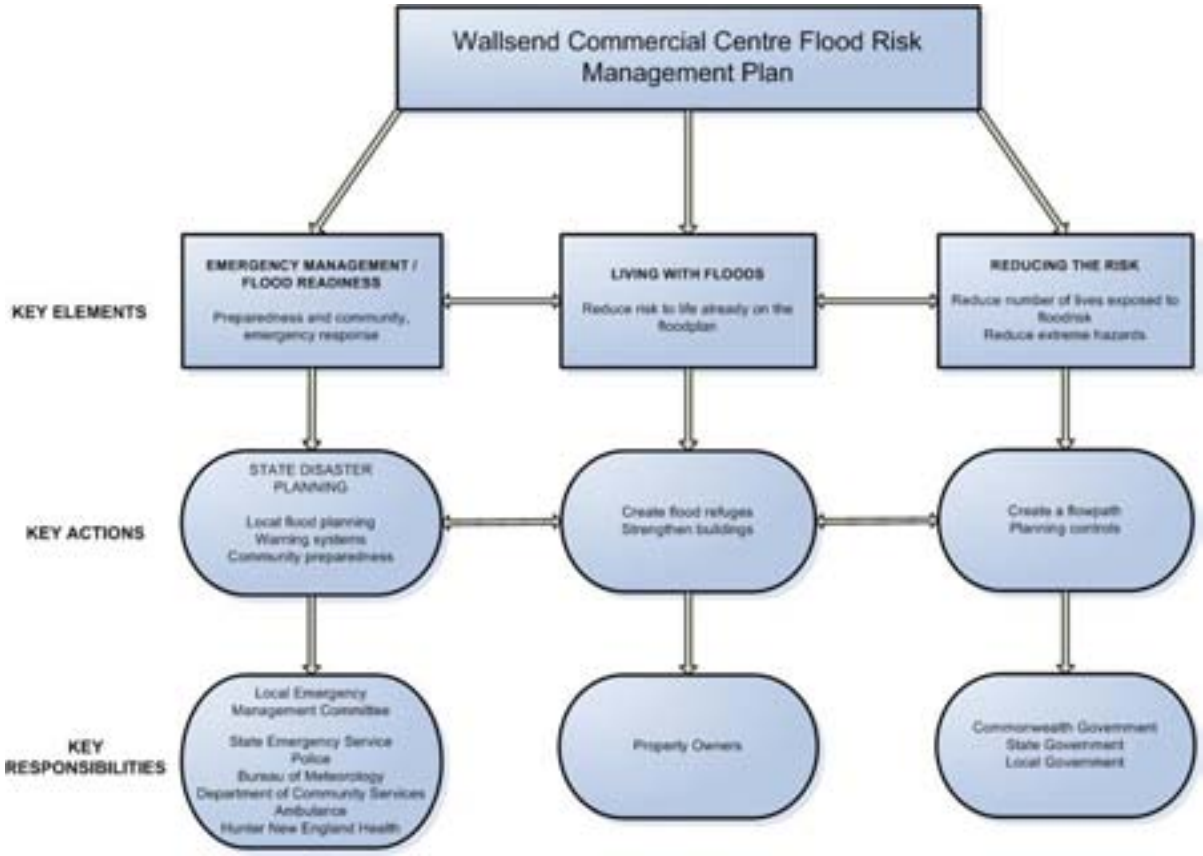
A local Flood Plan which is a subset of the Newcastle DISPLAN is recommended in this Study and would be a vehicle to keep the community informed and engaged over time.

7. POTENTIAL FLOOD RISK MANAGEMENT OPTIONS

This Section in the report forms the key component of the Flood Risk Management Study. Its purpose is to present a variety of management options as **potential** candidates for inclusion in the Plan as possible implementation schemes.

Options for consideration originated from community suggestions (refer Section 6) and from a workshop of flood experts convened in Wallsend on 6 February 2009. Each option has been considered in terms of its ability to contribute a positive flood risk management outcome, advantages and disadvantages and cost.

Potential options have been grouped together according to the following Chart:



7.1 Emergency Management / Flood Readiness – Potential Options

These potential options relate to matters that are the purview of many of the organisations who comprise Newcastle's Local Emergency Management Committee, such as the State Emergency Service.

Some of these potential options would require other options to be implemented – such as the creation of refuges under **Living With Floods** potential options.

7.1.1 Improve Warning Systems – Potential Option

Objective

Effective flood awareness, preparedness and appropriate flood emergency response can save lives, significantly reduce economic damages, give the community opportunity for choices before and during the flood and help reduce the shock through a sense of increased control and prior knowledge.

Description

In the Wallsend Commercial Centre the extremely rapid rise of dangerous fast flowing and deep flood waters provides no time for mobilisation and assistance from external sources such as the State Emergency Service. The safety of individuals will be utterly dependant on their not panicking and taking appropriate action to save their life.

A Flood Warning System must be developed and managed as a whole. A failure of one element can lead to complete failure. Although weather / environmental detection equipment and alarms are key elements, a complete flood warning system comprises:

- Data collection and transmission equipment
- Communication equipment (public and private) / protocols
- "Trigger" criteria
- Response to the "trigger" such as:
  - Monitor closely, OR
  - Issue advice such as:
    - Watch and wait for further advice, OR
    - Prepare (eg make sure refuges are accessible) OR
    - Act: (eg stay away from car parks and go to upper storey refuges)
- Predetermined, documented likely necessary evasive actions for a range of possible floods (up to the PMF) including definition of roles/responsibilities in addition to the ability to adapt and make decisions "on the fly".
- People who direct others (where and if needed)

- The affected community who need to respond (who therefore need to be aware and educated how to respond before the event).
- Maintenance (equipment, organisation and awareness).
- Performance review / improvement where available and warranted.

Ideally, any Flood Warning System would include data from outlying areas eg Lake Macquarie to provide early detection of emerging rainfall patterns.

Present Flood Warning Systems

In February 2006 the Bureau of Meteorology implemented an enhanced severe thunderstorm warning service in NSW and the ACT which uses graphics to better define the areas under threat when dangerous thunderstorms are occurring. The graphics complement the Bureau's traditional text-based warning service. Using radar based techniques a warning is issued and depicted on maps available on the internet. The maps show the general area of thunderstorm activity and individual cells are tracked at 10 minute intervals where it is judged they may produce a tornado, hail of diameter 2cm or greater, or wind gusts of 90 km/h or greater, or very heavy rain leading to flash flooding. The volatile nature of thunderstorms introduces uncertainty which is described in the Bureau's information about this system.

The Graphical Severe Thunderstorm Warning service does not meet all the flash flood warning needs of Wallsend. For example, flash flooding can be caused by storms that are not thunderstorms, and these will escape detection by this system. Also, the thunderstorms being tracked are shown for reasons in addition to or in combination with the possibility of flash flooding and therefore may not necessarily require a flash flood emergency response. There is no indication of how severe or where any rainfall will be so the severity of the flooding cannot be estimated. Finally, the information provided is only part of a total Flood Warning System (see "A Systems Approach" above).

At present, grant funding has been provided to Newcastle City Council to install telemetered rain gauges and water level sensors across the local government area. This equipment will provide real-time data to the Bureau of Meteorology who is responsible for advising the State Emergency Service and media of possible flash flood events. A base station providing back up to the system will be maintained by the Hunter Water Corporation. The Hunter Water Corporation's rain gauge at Wallsend Bowling Club will be upgraded and a new Water Level Recorder installed at Ironbark Creek as part of this system. Installation is expected to be completed by the end of April 2009. The equipment will be maintained by Hunter Water Corporation.

While the installation of this detection equipment will improve the information collected by the Bureau of Meteorology it falls far short of the systems approach outlined above. An emergency management plan (Flood Plan) which addresses public awareness raising, education and training and the existence of safe refuges is required for an effective Flash Flood Warning System. It is recommended that the Local Emergency Management Committee and the State Emergency Service ensure that the Wallsend community is informed and flood-ready and that a specific plan is in place for the Commercial Centre to respond to a flood emergency.

Disadvantages

To be fail safe, this strategy would need to be implemented in tandem with sufficient safe structurally sound refuges. It is pointless to encourage people to seek higher levels if they do not exist or are likely to collapse.

Costs and Funding

Costs are expected to be relatively small compared to most options. However, ongoing awareness raising, training and maintenance will need to be funded if the system is to be effective. Funding could be sourced through the Local Emergency Management Committee and an organiser such as the Bureau of Meteorology and SES.

Timing

Because of the risk to life posed by flash flooding in Wallsend *(and other catchments)* an emergency management plan (Flood Plan) including an early warning system should be implemented in the short term.

Implementation Steps

The Local Emergency Management Committee should develop and implement a Local Flood Plan for the Wallsend Commercial Centre as soon as practicable.

7.1.2 Flood Emergency Response and Preparedness Education – Potential Option

Objective

To reduce the risk to life associated with flash floods by appropriate flood emergency response and preparedness education of all Commercial Centre shop owners, site managers and the wider community.

Description

There has been little attention to community emergency response awareness and preparedness because the hazard, and risk to life associated with severe flash floods in Newcastle have not been understood. A joint Newcastle City Council/Hunter Water Corporation brochure on “Living with Floods in Newcastle” was sent to every ratepayer following the June 2007 floods. This built on an earlier publication specifically targeted at the Wallsend, Elermore Vale and Rankin Park residents in 2006.

However, the level of flood awareness created by the June 2007 flood will fade with time and needs to be continually reinforced with the public. Commemorative markers have been commissioned for the June 2007 flood event and will be placed in affected areas, such as Wallsend, in the first half of 2009.

Emergency response awareness and preparedness involves the education and training of individuals as well as the broader floodprone community. This is the responsibility of the State Emergency Service (*SES)* through the Local Emergency Management Committee. Council also has a role in assisting with the provision of specific information to promote flood readiness in their community.

A comprehensive program of community education and training *(in relation to key individuals)* needs to be set up and implemented. The program would need to consider issues such as:

- Flood depth indicators and flood warning signs;
- Special flash flood warning signs in carparks;
- Possible flash flood early warning methods such as sirens;
- Selection of flood wardens in commercial centre and a regular program of response training;
- Education on purpose and proper use of flood refuges;
- Preparation of individual site flash flood response plans throughout the commercial centre;
- Regular communications re: printed handouts, media broadcast and others; and
- Special requirements for large or difficult sites eg. The Plaza.
- People who may become trapped in vehicles on roads (as well as car parks)
- People with mobility limitations

Need/Benefit

Community awareness and preparedness about what actions should be taken when caught in a flash flood is vital to reducing the risk to life. If an extreme flash flood occurred tomorrow, many people could die because they do not know what to do.

The risk to life is reduced by having as many people as possible removed from exposure to the high hazards associated with severe flash floods. As it will never be possible to have a formal evacuation strategy in a flash flood setting, on site refuge is the only effective strategy. As discussed previously, such refuge will take time to create. In the interim, emergency response and preparedness education, in conjunction with preparation of site emergency response plans, is needed immediately to minimise loss of life if a severe flash flood were to occur before the flood refuge/structural strengthening is completed.

Such an interim position is not as bad as it may seem because the chance of a severe flash flood occurring over the next few years or so is very low.

Costs and Funding

Education programs need to be well managed and resourced if they are to be effective.

Funding should cover the cost of an Education Officer as well as costs associated with the preparation and printing of written material and the conduct of site training sessions. A notional cost of $175,000 pa is considered appropriate. It is assumed that this recurrent expenditure will be funded by the State and Federal Floodplain Management Grants Scheme *(2:2:1 subsidy)* for the duration of construction of major flood risk management facilities *(Commercial Centre flood refuge, Commercial Centre structural strengthening, Commercial Centre flood flowpath, Plaza elevated walkway, Commercial Centre velocity deflector walls)* and for 10 years after that i.e. for a period of 20 years.

Timing

Because of the relatively minor cost and its vital role in reducing the risk to life, the implementation of a Flood Emergency Response and Preparedness Education Program should be implemented as soon as possible.

Implementation Steps

Immediately commence preparation of a program in collaboration with the SES.

7.1.3 Flood depth indicator signs and commemorative markers / information – Potential Option

Public indicators of past and potential flooding has had mixed response in NSW. A number of communities have installed signage, painted telegraph poles, etc, and some of these have subsequently removed the indicators for possible political or social reasons. This concept is included as an item for consideration within the Flood Emergency Response and Preparedness Education option.

7.2 Living with Floods – Potential Options

These potential options primarily relate to private land. Some of these potential options would be dependent on options to Reduce the Risk (next section).

7.2.1 Commercial Centre Flood Refuges – Potential Option

Objective

To reduce the risk to life posed by flash floods in the Wallsend Commercial Centre by the creation of flood refuges.

Description

This category of works and actions applies to private land, where as a "whole of community" costs of implementation are proposed to the borne by owners (/ occupiers). In regard to businesses, the **Occupational Health and Safety Regulation 2001** states an employer must have arrangements in place in the event of emergencies. (Visit http://www.austlii.edu.au/au/legis/nsw/consol_reg/ohasr2001364/index.html or http://www.workcover.nsw.gov.au/Pages/default.aspx .)

Every industrial and commercial building of the Commercial Centre, which does not have a second storey, requires a mezzanine as a flood refuge. The flood refuge in Council's newly constructed public library is a good example.

Assuming that two storey buildings have adequate provision for flood refuge in their existing upper storeys, Council's property database indicates that there are approximately 58 single storey buildings which would require new upper storey refuges to be constructed.

A refuge would be of little value if the building would be likely to suffer substantial structural damage or fail in a severe flood. Hence a co-requisite of the creation of refuges is the structural strengthening of the building so that it can safely withstand the applied hydraulic loads of a severe flood. As the need for refuges applies to all buildings in the Commercial Centre wether they presently have an upper storey or not, structural strengthening is discussed separately below.

Benefit

The creation of flood refuges, with the co-requisite strengthening of all buildings in the Commercial Centre, allows all owners, employees and customers/visitors to greatly minimise risk to life by providing the opportunity to seek onsite refuge.

By properly addressing the risk to life, the substantial contribution of the Commercial Centre to the economy and lifestyle of the district would be sustainable.

Disadvantages

Retrospective requirements are always contentious. There is no legislative requirement for owners to build refuges which would make it difficult to monitor or enforce. The lack of legislation also creates problems with the practicality of accessing private properties to assess its structural integrity or assess the appropriateness of refuges once established. Funding may also be a sticking point with both government and private landholders both believing that the other party should bear the costs. Also, the time required for implementation and the cost of resourcing its coordination may be prohibitive. Finally, there is little point having refuges if they are going to be washed away. This measure needs to be combined with strategies to strengthen the buildings and/or reduce the impact of the waters.

Cost and Funding

In **Appendix B**, the cost of constructing 58 flood refuges is estimated to be $5.4 million. This does not include the Plaza Shopping Centre which is discussed separately in the following section.

As there would be significant economies of scale and a need to carry out construction on some groups of buildings simultaneously, the creation of flood refuges would desirably be implemented across the business community holistically. Piecemeal construction of flood refuges would be unlikely to be carried out by individual owners, certainly not in an orderly well managed fashion. It may be possible and certainly desirable for government funding incentives to be provided to property owners to undertake this work.

The provision of a flood refuge and attendant structural strengthening would provide a tangible benefit to each owner for the long term sustainability of their properties and businesses.

Timing

As it goes toward reducing the risk to life, the creation of flood refuges in the Wallsend Commercial Centre should have a high priority. As previously pointed out, some buildings in the Commercial Centre can suffer substantial structural damage which could endanger lives during a 1 in 100 annual chance or greater flood. The creation of refuges and strengthening of buildings should not be delayed. It is considered that all refuges should be constructed over a period of 5 to 10 years.

Priorities

Those buildings which can be heavily damaged during a 1 in 100 annual chance flood should have their refuges built first. That is to say priority should be given to buildings in Council, Tyrrell, Nelson and Boscawen Streets.

Implementation Steps

Property owners should:

- Carry out structural assessment of their buildings;
- Establish cost of constructing individual refuges *(plus structural strengthening)* or equitable proportion of costs if carried out as part of a group of buildings;
- Construct refuges; and
- Owners to prepare site evacuation plan to ensure appropriate preparations for use of refuge in a flash flood emergency.

7.2.2 The Plaza Shopping Centre – Refuge Potential Option

Objective

To reduce the risk to life posed by flash floods in the Plaza Shopping Centre and associated carparks.

Long Term Solution

The long term solution is to remove people and their cars from the path of flash floods, across the Plaza site, by major site rebuilding involving a multi-storey carpark and shopping areas all located above the PMF. The existing carpark would become a dedicated floodway with no parking allowed.

As the initiative, timing and funding of the long term solution would rest entirely with the owner; this possibility cannot be relied upon and given any time horizon in this Management Plan. However, as the Plaza Shopping Centre, and particularly its carpark, afford the greatest potential for loss of life in the Commercial Centre short term measures are required to manage the risk to life.

Short Term Solution

Until such time as the Long Term Solution is implemented the following interim risk to life management measures are needed:

Elevated Walkway

An elevated walkway within the Plaza and carpark with multiple internal and carpark feeders would help people stranded in the Shopping Centre and trapped in cars in the car park to evacuate to safety. The walkway would need to be of heavy steel construction to withstand the hydraulic loads of large floods *(with debris loading due to floating cars)* and be wide enough to allow rapid transfer of people to land adjacent to the Wallsend Library, above the PMF.

It may be possible to link the walkway to Plaza second storey offices to create a refuge for elderly or injured persons, subject to suitable structural strengthening of the building.

Preparation of Site Flash Flood Emergency Response Plan

A site evacuation plan needs to be prepared by the Plaza management to ensure the timely and appropriate use of the elevated walkway and orderly evacuation of the site *(as much as possible)*. The Plan should include:

- Linking with the Local Flood Plan prepared by the LEMC/SES;
- Permanent flood warning signs indicating use of walkway;
- Establish flood warning procedures and responsibilities;
- Install emergency power and lighting provisions;
- Establish evacuation procedures:
  - flood wardens
  - public address procedures
  - crowd marshalling
  - crowd control
- Training and preparedness of flood wardens and staff including emergency drills.

Flood Emergency Response and Preparedness Education Program

The SES, through the Local Emergency Management Committee should promote flood emergency response awareness and preparedness throughout the Commercial Centre generally with specific attention and communication to shop managers and Plaza Management.

Structural Strengthening

Structural strengthening of the Plaza building would need to be implemented by the Plaza Management.

Reduction of Local Hydraulic Loads

As part of possible works and measures to reduce hydraulic loads throughout the Commercial Centre, specialised flow deflector walls could be investigated and possibly constructed including the upstream wall of the Plaza. A suggested layout for such walls is discussed below.

Benefit

The Plaza Shopping Centre constitutes the single greatest risk to life in the Commercial Centre. Although the interim measures described above would not remove this risk to life, they would help to reduce the risk by affording shoppers and employees the opportunity to evacuate to safety. The flood awareness and preparedness provisions *(including site evacuation plans)* would help to inform people of the most appropriate action to take in a life threatening emergency.

Disadvantages

The main disadvantage is cost. Both the long term and short term solutions would involve a significant investment on the part of the Plaza owner and may not be considered feasible. Access to government funds for the interim measure may also be an issue. This strategy would need to be combined with structural strengthening, which would add to the cost.

Costs and Funding

The cost of providing an elevated walkway, 3m wide, with multiple internal and carpark feeders has been estimated to cost $3 million. The responsibility and cost of preparation of a Site Flash Flood Evacuation Plan would rest with the Plaza Management arising from its duty of care towards employees, lessees and the general public using the Centre.

While it may be possible for government funding incentives to be provided to the property owner to undertake this work, in general, it is being proposed that "Living with Floods" measures (on private land) implementation would be funded by the property owners, including this potential option of providing an elevated walkway.

Timing

Because the Plaza Shopping Centre constitutes the single greatest risk to life and because life threatening conditions can occur within parts of the carpark in a 1 in 100 annual chance, the short term works and measures should be accorded the highest priority.

Implementation Steps

The property owner should:

- Prepare a Site Flood Emergency Response Plan including liaison with the Local Emergency Management Committee and SES;
- Commence technical investigations and design of the building re structural strengthening of the building; and
- Establish a Flood Emergency Response and Preparedness Education Program for the site.
- Construct an elevated walkway.

7.2.3 Wallsend Commercial Centre Structural Strengthening – Potential Options

Objective

To reduce the risk to life by ensuring that all buildings in the Commercial Centre are structurally capable of withstanding the impact of an extreme flash flood.

Description

This is an essential co-requisite to the creation of refuges for one storey buildings and the Plaza short term measures to provide structural security for the essential flood refuges and related measures. It applies also to all two storey buildings, in the Commercial Centre, to ensure their viability as flood refuges.

There are 90 buildings which are classified as L_5/H_5 which would, on face value, mean that the flow conditions, associated with extreme floods, have too much energy to make structural strengthening feasible. Hence a co-requisite of structural strengthening is the reduction of flow hazards by works and measures which aim to reduce hazards to more manageable levels *(i.e. H_5 reduced to H_4 or H_3)*.

The extent of structural strengthening required will vary between buildings depending upon their structural condition, size and exposure to hydraulic loads. Hence a structural assessment of all buildings should be undertaken initially to ascertain the extent of structural strengthening required to withstand the hydraulic loads associated with an extreme flood.

Benefit

Structural strengthening is an essential co-requisite to the provision of mezzanine refuges on single storey buildings, and similarly essential for securing 2 storey buildings as safe refuges. As such, it is an essential component of reducing the risk to life associated with extreme floods.

Disadvantages

The strengthening of buildings will be a matter for individual property owners. There is no statutory requirement for property owners to undertake the strengthening work recommended. Access to qualified assessors and the cost involved could also be a problem. Other issues include the loss of internal space, the need for some external structures and the possibility that some buildings may not be able to be economically strengthened.

Cost and Funding

Structural assessment is estimated to cost $3,000 per building other than large buildings such as the Plaza Shopping Centre. With 90 buildings plus an allowance for some large buildings *(but not the Plaza)*, the cost of structural assessment is estimated to be in the order of $350,000.

The cost of strengthening each building will depend upon the results and recommendations of the structural assessment. For the purpose of preliminary costing of the Management Plan, a unit cost of $50,000 per small building and $200/m^2 for large buildings was adopted. On this basis, the cost of structural strengthening 90 buildings *(not including the Plaza)* could be in the order of $5 million.

As discussed in relation to the construction of refuges, structural strengthening should be carried out holistically across groups of buildings. While the cost of this work is likely to be borne by the property owners, it maybe possible for some financial assistance from the State and Commonwealth governments.

Timing

The structural assessment of the buildings should be carried out as soon as practicable. Strengthening works should be carried out as soon as possible. The strengthening of the single storey buildings should keep pace with the construction of mezzanine refuges.

Implementation Steps

Property owners should:

- Carry out structural assessment of all L_5/H_4/H_5 buildings as soon as practicable preferably within 12 months;
- Establish cost of strengthening each building and relative priorities;
- Obtain any necessary approvals; and
- Carry out works.

7.2.4 Relocation of the Commercial Centre – Potential Option

Objective

To consider whether the long term viability of the Wallsend Commercial Centre could be better served by avoiding the intractable flooding constraints through relocation.

Description

Given that strategic regional town planning options will likely arise in the future, consider the opportunity to re-locate the Commercial Centre to a flood free area and convert the existing Commercial Centre into park, recreation and sporting areas.

Such a scheme would have to be integrated into long term strategic planning goals and would likely take considerable time to become accepted and to implement.

Benefit

Relocation of the Commercial Centre out of the floodpath would ensure that the risk to life was minimal (assuming vacated areas are only used for flood compatible replacement purposes). It would prevent further distress and anxiety to the community and provide an environment in which commercial enterprises could flourish.

Disadvantages

The barriers to such a proposal should not be underestimated. Community ethos and identity is often deeply integral to the commercial centre and the disruption to the social fabric of the community would need to be carefully considered. There is also the question of compensation to property owners which would be very costly. The time taken to relocate the Centre would be considerable and there would be significant disruption to businesses and customers as it relocated over time.

7.2.5 Flood Proofing – Potential Option

Objective

To reduce immersion damage in buildings with a floor level above the 1 in 20 annual chance flood but less than the Flood Planning Level *(1 in 100 annual chance flood plus a freeboard of 0.3m)*.

Description

Floodproofing refers to the use of water resistant materials *(in floors, walls, doors and built-in furniture/cupboards)* and the siting of electrical fixtures, such as points, above the FPL to minimise the damage caused by floods which exceed floor level.

Benefit

Only applies to existing buildings.

Costs

Flood proofing is not eligible for funding under the subsidised Grants Program. Hence the cost of flood proofing would be borne by the individual property owners.

Timing

At the discretion of individual owners.

Implementation

Amend Newcastle DCP 2005 to emphasise the importance of flood proofing.

Costs

The costs of relocating the Commercial Centre are unable to be estimated. It is anticipated that there would be considerable negotiation between Governments and private owners over responsibility and compensation.

Timing

Relocation would need to be gradual (say 20 years) following considerable community consultation.

Implementation Steps

Implementation would require setting aside land in a more suitable location nearby for commercial use. It would be imperative that the Plaza was supportive of moving to higher ground, thereby attracting the smaller businesses. Community consultation would be ongoing.

7.3 Reducing the Risks – Potential Options

These potential options relate to works that would be constructed public land and the functions of Government, noting that some of the components of some of these potential options relate to private land such as planning controls and acquisition of private land.

7.3.1 Create Flow Path Potential Options

To reduce the force of flash flood waters in extreme events (where the risk to life is greatest) from present conditions where most buildings (including Wallsend Plaza Shopping Centre) would be in danger of collapse, to a lesser force which would enable practical strengthening of buildings as a pre-requisite to providing upper storey refuges.

There are two main components:

- Increasing the flow capacity under Minmi Road, and
- Removing buildings and some bridges, and widening the channel.

There are two possible configurations for widening the channel:

- Create a Short Channel Flow Path in the lower portions only of the Wallsend Commercial Centre OR
- Create a Long Channel Flow Path through the entire Wallsend Commercial Centre.

Each scenario configuration was tested in the computer flood model as a single potential option. That is the following scenarios were tested:

- Commercial Centre Short Flow Path together with increased flow capacity under Minmi Road AND
- Commercial Centre Long Flow Path together with increased flow capacity under Minmi Road

The results and cost analysis indicated that while second option (which involves the purchase and removal of many more buildings) gave marginally more reduction of flood hazards, the estimated cost was significantly more. Both configurations would meet the objective of reducing the flood hazard category sufficiently to enable strengthening of buildings to withstand the full range of estimated flood forces so that the creation of refuges would become achievable.

The individual components of the two possible flow path configurations are described and reviewed in the following three sections:

INCREASE FLOW CAPACITY ACROSS MINMI ROAD

Objective

To reduce the risk to life associated with the increased water levels in the Commercial Centre caused by the confluence of floodwaters at the intersection of Minmi Road and Ironbark Creek during a large flood event.

Currently, all buildings within the Commercial Centre are designated as a H_5 Hazard in an extreme flood event. A large proportion of these buildings would be severely damaged, leading to the likely possibility of injuries and/or deaths. The structural reinforcement of older buildings, in order to prevent critical damage within a H_5 Hazard area, is not possible. Therefore the objective of the downstream channel is to reduce flood levels across Federal Park and thus lower hazards through the downstream part of the Commercial Centre. This is to be achieved by reducing the backwater effect of Minmi Road through the creation of a wide channel from the northern end of Federal Park to the low land in Hexham Swamp north of Minmi Road.

Description

In order to be effective, the flowpath leading to, and beneath, Minmi Road must have a sufficiently large cross-sectional area in order to convey flows during an extreme flood event. By minimising the restriction at this point, floodwaters in the Commercial Centre will be “allowed” to drain more efficiently, leading to lower flood levels and a hazard reduction across the downstream portion of the Commercial Centre.

To achieve this, an average channel width of 55m was chosen, beginning at the north side of Federal Park, continuing approximately 75m north past Minmi Road into the low area of Hexham Swamp. In order to successfully funnel flows from Federal Park into the channel (and therefore beneath Minmi Road) an entrance width of approximately 75m was selected.

At the outlet, the channel expands to a width of approximately 80m, with an apron across Hexham Swamp excavated gradually to merge the channel with the adjacent terrain.

Details of the proposal are as follows:

Excavation	The channel is proposed to have a trapezoidal cross-section, maintaining the lower portions of Ironbark Creek. The channel's base would be excavated to an elevation of 1m AHD at the Federal Park entrance and graded to an elevation of 0.4m AHD at the downstream end. The sides of the channel would have slopes of 1 in 3 to merge with the existing terrain. The majority of the channel would be grass covered, with the original portions of Ironbark Creek now being lined in concrete.
Bridge Construction	The bridge at Minmi Street would require an extension or total redevelopment in order to cross the larger channel. It is important that the Minmi Street bridge does not undermine the objective of the project by restricting flow in the channel. Costs given in this report have been estimated based on complete demolition of the existing bridge and replacement with new larger Deck/Girder style bridge.

Benefits

The changes described above were modelled in Council's two dimensional flood model in conjunction with the short and long Commercial Centre flow paths as described below. These works reduce flood levels across Federal Park and the northern end of the Commercial Centre by 0.45m for the extreme flood. More significant benefits could be expected for lesser floods where Minmi Road is not overtopped.

Disadvantages

Apart from costs, there may be problems associated with environmental issues and impacts on adjacent properties. The reduction in flood level does not impact on the time available to respond to a flash flood nor does it reduce the impact of flood waters on the buildings. This initiative is supplementary to improving flow paths through the commercial centre.

Costs

Detailed costings of the civil works are provided in **Appendix B**. The total cost of developing the downstream flow channel is in the order of $5.4 million with the most significant element being the new bridge at Minmi Road.

Figure 19 shows the proposed layout of the Downstream Channel Flow Path.

Figure 19 - Downstream Channel Schematic Configuration

COMMERCIAL CENTRE SHORT CHANNEL FLOOD FLOW PATH

Objective

To reduce the risk to life by expanding the flowpath through the core of the Commercial Centre. This would reduce overland flood discharge and the associated hydraulic hazards during large flood events.

Currently, all buildings within the Commercial Centre are designated as a H_5 Hazard in an extreme flood event. A large proportion of these buildings would be severely damaged, leading to the possibility of injuries and/or deaths. The structural reinforcement of older buildings, in order to prevent critical damage within a H_5 Hazard area, is not possible. Therefore the objective of the Commercial Centre Short Channel Flow Path is to reduce hazards below an H_5 level by expanding the flow path through the 'dam' caused by the Nelson Street shops and diverting flows from the Shopping Plaza car park into this channel.

Description

In order to be effective, the flow path through the Commercial Centre must have a sufficiently large cross-sectional area in order to convey significant flows during an extreme flood event. Additionally, flows through the Shopping Plaza car park which conveys half of the peak discharge of the PMF will need to be efficiently fed into this wider channel.

To achieve this, an average channel width of 45m was chosen based on a maximised feasible Commercial Centre layout, beginning at the north side of the Shopping Plaza car park and continuing to the Federal Park side of the Boscawen Street Bridge along Ironbark Creek. In order to successfully direct all flows from the car park into the channel, an initial channel width of approximately 90m was selected.

Details of the proposal are as follows:

Acquisition and Demolition	At least eight industrial, commercial and residential properties are required in order to create the channel through the Commercial Centre. Bridges at Tyrrell and Boscawen Streets would be required to be demolished.
Excavation	The channel is proposed to have a 'U-shaped' cross-section in order to maximise its potential flow conveyance. The channel's base would be excavated to a height of 1.75m AHD at the Shopping Centre Car Park entrance and graded to a height of 1.25m AHD at the Federal Park side exit to the channel. The channel would be concrete-lined.
Bridge Construction	The bridge at Nelson Street would require an extension or total redevelopment in order to not only cover the now larger channel, but also in order to convey the increased traffic volume as a result of the closure of the Tyrell and Boscawen Street Bridges. Costs given in this report have been estimated based on complete demolition of the existing culvert style bridge and replacement with new larger Deck/Girder style bridge.
Tyrrell Street Works	An area no greater than 200m^2 of Tyrrell Street, adjacent to Nelson Street, would be raised as a pseudo-levee, in order to increase the time for evacuation along Nelson Street.

Figure 20 shows the proposed layout of the Commercial Centre Short Channel Flow Path.

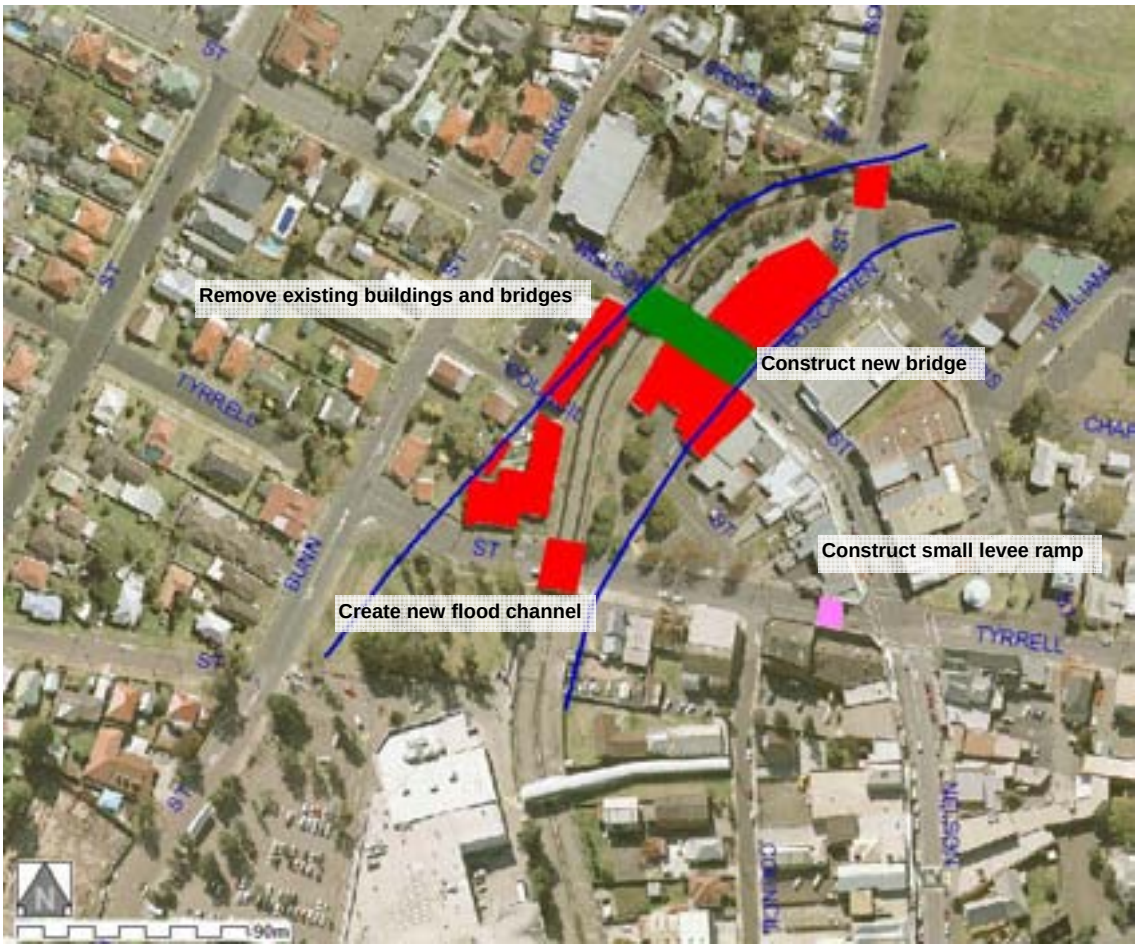


Figure 20 - Commercial Centre Short Channel Flow Path

Benefits

The changes described above were modelled in Council's two dimensional flood model in conjunction with the downstream channel widening. The preliminary modelling indicates that many of the streets within the Commercial Centre would see their hazard reduced from H_5 to H_4.

As indicated above, peak PMF flood levels would be reduced by 0.45m across the northern part of the Commercial Centre as a result of the downstream channel widening which would reduce the flood forces on buildings sufficient to make strengthening of the buildings viable. The short channel flow path would provide additional benefits upstream by reducing peak PMF flood levels by 0.9m along Council Street, by 0.65m in the Plaza carpark, and by 0.55m at Cowper Street.

Disadvantages

There would be marginally less economic activity as a result of removing the buildings. Owners of the buildings to be purchased may be reluctant to sell and unless the NSW Flood Program receives significantly more funding it may take many years to buy the buildings. Unless managed sympathetically, the resulting open space (channel and adjoining land) could appear sterile and unattractive. There are also issues with safety and vandalism.

Costs

Detailed costings of the civil works are provided in **Appendix B**. The total cost of developing the short flow channel is in the order of $15.4 million with property acquisition costs likely to be in the vicinity of $8.5 million

COMMERCIAL CENTRE LONG CHANNEL FLOOD FLOW PATH

Objective

To reduce the risk to life by vastly widening and redirecting the flowpath through the Commercial Centre, leading to a reduction in overland flood discharge and associated hydraulic hazards during large flood events.

Currently, all buildings within the Commercial Centre are designated as a H_5 Hazard in an extreme flood event. A large proportion of these buildings would be severely damaged, leading to the likely possibility of injuries and/or deaths. The structural reinforcement of older buildings, in order to prevent critical damage within a H_5 Hazard area, is not possible. Therefore the objective of the Commercial Centre Long Channel Flow Path is to reduce hazards to below an H_5 level by bypassing a large portion of the Commercial Centre.

Description

In order to be effective, the flow path through the Commercial Centre must have a sufficiently large cross-sectional area in order to convey significant flows during an extreme flood event. Additionally, some of the flow that bypasses the channel along Tyrrell Street could be reduced in order to maximise the desired effects.

To achieve this, an average channel width of 45 m was chosen based on a maximised feasible Commercial Centre layout, beginning on the Wal Herd Park side of the Cowper Street Bridge and continuing to the Federal Park side of the Boscawen Street Bridge along Ironbark Creek. In order to ensure the flows through Wal Herd Park are successfully fed into the newly created channel, two additional modifications are required. Firstly, a localised graded 'funnel' is required to be excavated adjacent to the Cowper Street Bridge functioning as a 'mouth' to the channel. Secondly, a flow deflection wall is required on the eastern and northern sides of the park so as to direct flows that would normally leave the park area, into the mouth of the channel.

Details of the proposal are as follows:

Acquisition and Demolition	At least a dozen industrial, commercial and residential properties are required in order to create the channel through the Commercial Centre. Bridges at Tyrrell and Boscawen Streets would be required to be demolished.
Excavation	The channel is proposed to have a 'U-shaped' cross-section in order to maximise its potential flow conveyance. The channel's base would be excavated to a height of 2m AHD at the Wal Herd Park entrance and graded to a height of 1.25m AHD at the Federal Park side exit to the channel. The Wal Herd Park mouth would be graded down to 2m AHD from all sides with a slope of 1 in 3. The channel would be concrete-lined.
Bridge Construction	The bridges at Nelson and Cowper Streets would require an extension or total redevelopment in order to not only cover the now larger channel, but also in order to convey the increase traffic volume as a result of the closure of the Tyrell and Boscawen Street Bridges. Costs given in this report have been estimated based on complete demolition of the existing culvert style bridges and replacement with new larger Deck/Girder style bridges.
Tyrrell Street Works	An area no greater than 200m^2 of Tyrrell Street, adjacent to Nelson Street, would be raised as a pseudo-levee, in order to increase the time for evacuation along Nelson Street.
Wal Herd Park Deflection Wall	A concrete wall, no higher than 1.5m, running along the northern and eastern border of Wal Herd Park would be required to divert flows into the channel that would potentially leave the park.

Figure 21 shows the proposed layout of the Commercial Centre Long Channel Flow Path.

Benefits

The changes described above were modelled in Council's two dimensional flood model in conjunction with the downstream channel widening. The preliminary modelling indicates that many of the streets within the Commercial Centre would see their hazard reduced from H_5 to H_4.

As indicated above, peak PMF flood levels would be reduced by 0.45m across the northern part of the Commercial Centre as a result of the downstream channel widening which would reduce the flood forces on buildings sufficient to make strengthening of the buildings viable. The short channel flow path would provide additional benefits upstream by reducing peak PMF flood levels by 0.9m along Council St, by 0.6m in the Plaza carpark, and by 0.5m at Cowper Street.

Disadvantages

There could be less economic activity as a result of removing the buildings. Owners of the buildings to be purchased may be reluctant to sell and unless the NSW Flood Program receives significantly more funding it may take many years to buy the buildings. Unless managed sympathetically, the resulting open space (channel and adjoining land) could appear sterile and unattractive. There are also issues with safety and vandalism

Costs

Detailed costings of the civil works are provided in **Appendix B**. The total cost of developing the short flow channel is in the order of $26.5 million with property acquisition costs likely to be in the vicinity of $12.2 million

Figure 21 - Commercial Centre Long Channel Flow Path

7.3.2 Commercial Centre Velocity Deflector Walls – Potential Option

Objective

To reduce the risk to life in the Commercial Centre associated with large water depths and velocities during an extreme flood event.

Currently, all buildings within the Commercial Centre are designated as a H_5 Hazard in an extreme flood event. A large proportion of these buildings would be severely damaged, leading to the likely possibility of injuries and/or deaths. The structural reinforcement of older buildings, in order to prevent critical damage within a H_5 Hazard area, is not possible. Therefore the creation of a series of deflector walls in the Commercial Centre has the objective of reducing hazards below a H_5 level by reducing the impact of the flow velocity on targeted areas.

Description

In order to be effective, the deflector walls must be placed in strategic locations and must be of sufficient height so that flood waters are impeded and redirected, thereby protecting building structures from the associated hazards.

To achieve this, 13 wall segments were placed in key locations around the Commercial Centre, based on the direction of flow and depth during the 500yr ARI and PMF events. If the wall were to be constructed based on 500yr ARI levels, an average wall height of 1.25m would be required, with wall heights ranging between 0.7m and 2.6m. If the wall were to be constructed based on PMF levels, an average wall height of 3.35m would be required, with wall heights ranging between 2.4m and 4.8m.

It must be remembered that the objective of removing the H_5 level hazards is in direct relation to the PMF flood event. Whilst deflector walls based on the 500yr ARI event will without doubt prevent a large portion of the flow velocity from impacting on the Commercial Centre during a PMF event, it will obviously not impede flows above the wall, which will generally be 2 metres above 500yr levels.

In either case, a primary reinforced concrete wall thickness of 0.2m will be used with buttresses as required. The base of the wall will be thicker and anchored in the surrounding soil to an appropriate depth. A conservative estimate was used for cost calculations. The total combined length of the deflector walls will be in the order of 1.4km in 13 primary sections.

Further details of the proposal are as follows:

Wall Section	*Average Height (based on 500yr ARI event)*	*Average Height (based on PMF event)*
1	0.7	3.0
2	1.1	3.4
3	0.8	2.8
4	0.9	3.6
5	1.5	4.0
6	2.6	4.8
7	1.5	3.7
8	1.1	3.2
9	1.3	3.1
10	1.0	2.5
11	1.0	2.5
12	0.8	2.4
13	1.0	3.0

Figure 22 shows the proposed layout of the deflector walls.

Figure 22 - Flow deflector walls

Benefits

This work is an adjunct to the strengthening of buildings for on-site refuge to reduce velocity induced hazards of H_5 to H_4 so that the older buildings can be made fail safe.

Disadvantages

The key disadvantage with this option would be the visual impact on commercial premises of the deflector walls. The walls would impact on access to these premises and present a canvas for graffiti. The visual impact on the Commercial Centre may alienate visitors/customers to the shopping streets. This proposal is not compatible with the need for good access and permeability through the shopping centre.

Costs

Detailed costings are provided in **Appendix B**. The total estimated cost of the walls is in the order of $2 million

7.3.3 Extend the concrete lined channel from Federal Park to the bridge under Minmi Rd – Potential Option

Objective

To reduce the level of water by evacuating flood waters at a faster rate out of the Commercial Centre.

Description

The perception that smooth channels will evacuate flood waters faster is true when the water has somewhere to rapidly disperse downstream across the floodplain or downhill. This section of the stream lies at the lower end of the creek where floodwaters cannot disperse rapidly for several reasons. Normal water levels within Hexham Swamp are controlled by ocean tide levels eliminating any downhill dispersal. Lateral dispersal across Hexham Swamp downstream of Minmi Road is limited by the spoil banks of the channel and the nearby ground levels of the floodplain. The bridge opening under Minmi Road forms a constriction limiting the amount of flow that can pass through to the swamp.

Benefit

Although the effect is limited, some improvements can, however be made, as detailed below in the Downstream Channel option, but they require more extensive works than just lining the channel.

Disadvantages

There is no impact on flood levels in the case of extreme flooding when Minmi Road is overtopped.

7.3.4 Construct Detention Basins – Potential Option

Objective

To reduce the risk to life by reducing the rate of rise of flash floods and thereby provide more time for people to seek safe refuge.

Description

A detention basin, involving excavation, in Elermore Vale *(i.e. Elermore Vale Detention Basin)* was investigated.

Approximately six hectares of the Elermore recreation area would be excavated to a depth of between 1.8-2.7 metres, depending upon final design. This would create a minimum storage volume of approx 108,000m^3 to retard the passage of a flash flood. Cardiff Road would act as the retarding wall and no additional construction would be required apart from minor flow control structures *(low level weir and approach and exit aprons and wing walls)* at the crossing under Cardiff Road. All excavated material would be trucked away from site.

The surface of the basin would be appropriately graded and the playing fields re-established so that there would be no loss of these facilities.

Benefit

There are no material benefits for the floods that pose severe risks to life. Even attempting to "take the edge off" smaller events would require more land than is reasonably available in existing open space areas.

The majority of areas have less than 150mm reduction in peak water levels, where peak depths are many metres. The estimated delay is only about five minutes in the peak, which offers no material benefit for emergency responses.

Disadvantages

There is no impact on flood levels in the Commercial Centre during a PMF. Peak Flood levels in an extreme event would only be delayed by about five minutes. This provides no material advantage when responding to extreme events. Apart from costs, there may be problems associated with health and safety issues. For example, the public use of large areas of public open space would be compromised in normal times, and the community may believe all flood risks have been removed, which may lead to a false sense of security when flooding occurs.

Costs and Funding

Detailed costings are provided in **Appendix B**. The cost of the Elermore Vale basin is largely dependent upon the scale of excavation involved. Estimates have been carried out assuming a maximum excavation to RL10.0 which is slightly above the invert level of Ironbark Creek at Cardiff Road. This would involve an average depth of excavation of approximately 2.7 metres. Costs are estimated to be in the order of $8.13 million

The works would be eligible for funding under the State and Federal Floodplain Management Grants Scheme on a 2:2:1 subsidy basis.

7.3.5 Rainwater tanks and distributed detention – Potential Option

There is often a common perception within flood affected communities on small catchments, that the widespread installation of domestic rainwater tanks and numerous small detention basins in parks and reserves will solve many of the flooding problems by capturing a quota of the rainfall and releasing it after the flood has passed.

There is some merit in this concept improving flood conditions immediately downstream of each storage device provided the device was empty prior to the storm. However, in the case of the Commercial Centre, at the downstream end of the catchment, the concept has a number of problems. The Commercial Centre lies across the Ironbark Creek floodplain, the purpose, of which is to convey flood flows when the creek channel capacity is exceeded. Natural channels typically have capacities for conveying 1 in 5 annual chance floods (*or thereabouts*), after which the floodplain becomes activated. Modifying this natural process would require the storage of enormous volumes of water, akin to large dams.

Smaller changes to flood levels may be achievable, but to have any significant effect at the downstream end of the catchment, the storage volumes will still have to be very large, and the further upstream from the Commercial Centre the storage is, the greater the volume will need to be.

By way of example, if we were to consider reducing the 1 in 100 annual chance flood to a 1 in 20 annual chance flood, we would have to store the difference in volumes between the two floods, an amount of 270,000 m^3. Constructing this storage within the floodplain immediately upstream of the Commercial Centre at 1.3m deep, would require all of the playing fields and park area from Cowper Street to Croudace Road. Likewise more than 150,000 rainwater tanks or 60 to 80 small park and reserve storages would be needed.

Whilst a combination of these storages may provide some relief for smaller floods, provided they were empty at the start of the storm, they would not mitigate the risk to life issues faced by the Commercial Centre.

7.3.6 Remove Wallsend Plaza – Potential Option

Objective

To reduce the level of flooding by removing the obstruction of the Plaza Shopping Centre from the floodway.

Description

During rare floods, a significant portion of the total flow passes through the Plaza carpark, re-joining the channel at Nelson Street. Thus it would appear conceivable that removal of the shopping centre should improve flooding conditions. However the shops along Nelson Street form a partial 'dam' to flows passing downstream. This situation causes an increase in water levels upstream in order to force the flow through the narrow opening at the channel and bridge. Widening this narrow opening will bring improvements, but without this widening, removal of the shopping centre will merely re-distribute the flows over a wider area, lowering velocities but not affecting water levels.

Flood modelling of this option showed peak flood level reductions for the PMF, of 0.1m through the Plaza carpark and upstream, with consequent increases of 0.01m to 0.05m downstream of the shopping centre.

Benefit

There were no material benefits revealed by the investigation of this option.

Disadvantages

The loss of a major retail facility.

7.3.7 Amend Newcastle Planning Documents – Potential Option

Objective

To ensure that Newcastle City Council Planning documents support the management of risk to life and property during an extreme flash flood.

Description

Newcastle City Council has a number of land use planning policy documents which manage and direct the sustainable growth of Newcastle and its surrounds. These include the Newcastle Urban Strategy 2005, Local Environment Plan and Newcastle Development Control Plan 2005. One element of the existing DCP is on floods. At present these documents are being reviewed.

Some elements of these documents are not considered to be wholly consistent with the measures and procedures identified in this Study. The findings from this study should be incorporated where relevant into the documents during the Review process.

7.3.8 Channel and Culvert Maintenance – Potential Option

Objective

To maintain bridge openings, culverts and channels to their intended full flow areas.

Description

Channel maintenance is part of Council's annual maintenance programs. However, channel maintenance in the past has been spasmodic and the community has complained over the build-up of sediment and debris in the system from time to time. Whilst it is clear that Council needs to put more resources into channel maintenance, the benefits from a flood risk management viewpoint are limited.

Maintenance is not the panacea often perceived by the community. The discussion below places channel maintenance into a risk perspective.

Flood Risk Management Perspective

Although the broad topography is largely unchanged in the catchment and floodplain, human influence has highly modified many previously natural feature such as creeks and wetlands. Creeks have been concrete lined or reshaped and wetlands have been filled for example. The designers of these works never had very major or extreme floods in mind.

Elsewhere in this report it has been described that in very major or extreme floods *(with some of these even larger than what has been experienced since European settlement)* the human modified and constructed drainage system will be overwhelmed. Experience has shown that during floods large volumes of debris can be released, such as trees, fence sheeting, wheeled waste containers and vehicles. Even if the existing drainage systems are completely clean just before a flood, there is still every chance that debris will cause a reduction in the capacity of the drainage system. The larger the flood the more chance there is of debris being released.

In a modified drainage system, there will be potential benefits of improved flow capacity if these systems are maintained so as to preserve the designer's intended flow area of channels bridges and culverts. The potential benefits would be more likely to be realised during smaller floods, and since these smaller floods on average occur more often, the potential benefits would be expected to justify the maintenance. Smaller floods in general are more likely to predominantly adversely affect property and not pose a great risk to life.

In relation to very large to extreme floods, which pose the greatest risk to life, a maintenance regime that preserves the intended flow areas of channels, bridges and culverts will have relatively little benefit because:

- The flow in the bridges, channels and culverts is overwhelmed by flood water that flows overland and through buildings; and
- The flow areas in the bridges, channels and culverts are far more likely to be impeded by significant amounts of debris released during the course of the flood.

Considering all the above, it is considered that the intended full flow areas of bridges, channels and culverts should be maintained between floods *(consistent with relevant legislation and other policies)* in order to reduce the chances of damage to property.

Implementation

It is recommended that Council increases its annual channel maintenance to maintain Ironbark Creek and its tributaries to their full intended flow area, especially through the Commercial Centre.

7.3.9 Measures to Manage Cumulative Impacts - Potential Option

Objective

To produce a map which defines Floodway, Flood Storage and Flood Fringe areas of the floodplain of Ironbark Creek through the Commercial Centre.

Purpose

The determination of these categories is a crucial strategic exercise which considers the cumulative impact of all future development, across the full range of floods *(including the PMF)* across the entire floodplain.

Section 3.2 describes how this strategic exercise was carried out for the Wallsend Commercial Centre to produce the hydraulic categories map shown in **Figure 14**.

Figure 14 is needed to support Newcastle DCP 2005 and LEP. To date such a plan has not been available and preliminary information has been available only *(NCC Flood Atlas, 2004)*.

The Map

Figure 14 will support the Newcastle City LEP and DCP *(2005)* and ensure that no significant filling or constriction of the floodplain will occur in the area identified as Floodway. As outlined in Section 3.2, development within the flood fringe area can take place without any risk of significant cumulative impact on the existing flood hazard regime.

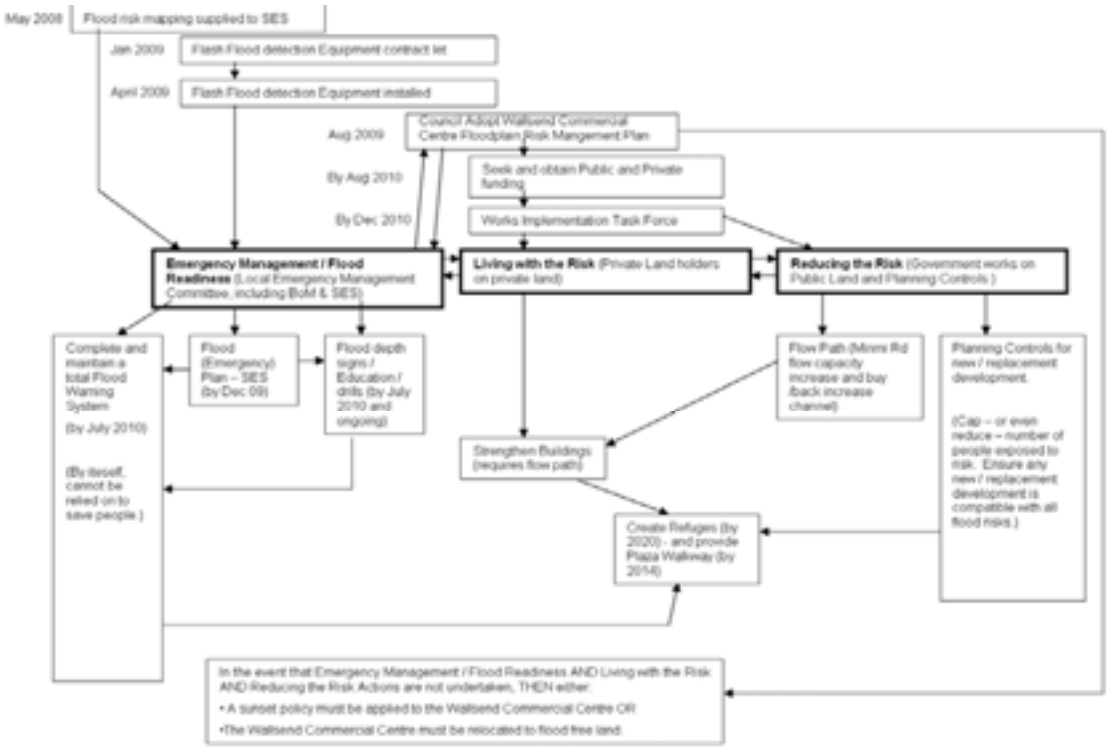
8. RECOMMENDED FLOOD RISK MANAGEMENT OPTIONS

The following package is recommended:

Category	Draft Measures	Risk to Life		Risk to Property		Concept Costs
		Can	Cannot	Can	Cannot	
Emergency Mgt / Flood Readiness	•Warning •Education •SES Plan	•Inform •Prepare	•Save many people •Stop flooding	•Inform •Prepare •Reduce losses	•Eliminate all losses •Stop flooding	To be defined by LEMC
Living with the Risk	•Refuges •Strengthen buildings * •Walkway	•Save people	•Stop flooding	•Protect Buildings	•Stop flooding •Protect Stock	$16M
Reducing the Risk	•Flow Path •Planning controls •Insurance	• *enable strengthening •Reduce exposure	•Stop flooding	•Reduce Exposure	•Stop flooding	$28M
						$44M +

Each of the three key elements – **Emergency Management and Flood Readiness**; **Living with Floods** and **Reducing the Risk** - need to come together as a single "Package" to reduce the flood risk in the Wallsend Commercial Centre. For example, a flash flood warning system cannot be solely relied on to save people since it is not fail safe and since it cannot always provide sufficient warning for large numbers of people to escape to high ground, leaving them trapped with no escape. Therefore on site refuges are required, which in turn will not be feasible unless buildings are strengthened to withstand the forces of flooding, and which in turn is unlikely to be feasible unless works are undertaken to reduce the forces of flooding on buildings. Although some of the management measures of the Plan are aimed at marginally reducing floods it must be recognised that severe flash flooding will always be part of the Wallsend Commercial Centre.

Recognising these interdependencies, and the need to put measures in place to manage the extraordinary risks to life then requires the following implementation strategy:



The development and implementation of a Floodplain Risk Management Plan is a partnership. No single organisation, person or group of people has an entire responsibility for all management of flood risks. Instead, a coordinated, unified and partnered approach is required to successfully manage flood risks. We should therefore think of a whole of community "Partnership of Floodplain Management" consisting of affected and interested people, community groups and associations, Government agencies and Council working together.

It is proposed that Emergency Management and Flood Readiness implementation would be resourced and funded from emergency management agencies (such as the SES and Bureau of Meteorology), that "Living with Floods" measures (on private land) implementation would be funded by the property owners, and that implementation of "Reducing the Risk" measures would be funded by Government, all coordinated through an implementation Task Force.

In the event that the hazard reduction measures are not undertaken it is recommended that either:

- A sunset policy be applied to the affected area of the Commercial Centre (excluding any future development or re-development which would be required to be compatible with the flood risks)

  OR

- The Wallsend Commercial Centre be relocated to flood free land.

The detailed design of any works dependent on quantifying flood flows and forces should be carried out using a further more finely detailed and refined computer flood model to ensure all impacts and design forces are properly taken into account.

9. REFERENCES

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10. GLOSSARY

The following Glossary of Terms has been extracted from the separate document:

Newcastle City Council, August 2008, '*Wallsend Plattsburg (Ironbark Creek) Flood Study',* report by DHI Water & Environment Pty Ltd

This glossary is based on the glossary of terms published in the New South Wales Government Floodplain Management Manual (2005).

Annual Exceedance probability (AEP)
The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood of discharge 500 m3/s has an AEP of 5%, it means that there is a 5% chance of (that is one-in-20 chance) of a peak flood discharge of 500m3/s or larger occurring in any one year (see average recurrence interval).

Australian height datum (AHD)
A common national plane of level corresponding approximately to mean sea level.

Average recurrence interval (ARI)
The long term average number of years between the occurrence of a flood as big, as or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

Cadastre, cadastral base
Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses, etc.

Catchment
The land area draining through the main stream, as well as tributary streams to a particular site. It always relates to an area above a particular location.

Digital Elevation Model (DEM)
A digital representation of ground surface topography or terrain.

Discharge
The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).

Flash flooding
Flooding which is sudden and unexpected. It is often caused by sudden local heavy rainfall. Often defined as flooding which peaks within 6 hours of the causative rain.

Flood
Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, lake or dam and/or overland flooding associated with major drainage before entering a watercourse and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

Flood fringe areas
The remaining area of flood prone land after floodway and flood storage areas have been defined.

Flood liable land
Is synonymous with flood prone land (i.e.) land susceptible to flooding by the probable maximum flood (PMF) event. Note that the term flood liable land now covers the whole of the floodplain not just that part below the flood planning level as indicated in the 1986 Floodplain Development Manual (see flood planning area).

Flood mitigation standard
The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.

Floodplain
Area of land, which is subject to inundation by floods up to, and including the probable maximum flood event, that is, flood prone land.

Floodplain risk management options
The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.

Floodplain risk management plan
A management plan developed in accordance with the principles and guidelines of the NSW Government Floodplain Management Manual 2001. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.

Flood plan (local)
A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.

Flood planning area
The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the “flood liable land” concept of the 1986 Floodplain Development Manual.

Flood planning levels (FPLs)
Are the combinations of flood levels and freeboards selected for the planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans. The concept of flood planning levels supersedes the “standard flood event” of the 1986 Floodplain Development Manual.

Flood prone land
Is land susceptible to flooding by the probable maximum flood (PMF) event. Flood prone land is synonymous with flood liable land.

Flood risk
Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk is divided into 3 types, existing, future and continuing risks. They are described below.

Existing flood risk
The risk a community is exposed to as a result of its location on the floodplain.

Future flood risk
The risk a community may be exposed to as a result of new development on the floodplain.

Continuing flood risk
The risk a community is exposed to after flood risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing risk is simply the existence of flood exposure.

Flood storage areas
Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity and loss of flood storage can increase the severity of flood impacts by reducing the natural flood attenuation. Hence it is necessary to investigate a range of flood sizes before defining flood storage areas.

Floodway areas
Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels.

Freeboard
A factor of safety typically used in relation to the setting of floor levels, levee crest levels etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement and other effects such as “greenhouse” and climate change. Freeboard is included in the flood planning level.

Geographical Information Systems (GIS)
A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.

Hazard
A source of potential harm or a situation with a potential to cause loss. In relation to the NSW Floodplain Management Manual 2001 the hazard is flooding which has the potential to cause damage to the community.

Hydraulics
The term given to the study of water flow in waterways, in particular, the evaluation of flow parameters such as water level and velocity

Hydrograph
A graph that shows how the discharge or stage/flood level at any particular location changes with time during a flood.

Hydrology
The term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.

Local overland flooding
Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.

Mainstream flooding
Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

Major drainage
Councils have the discretion in determining whether urban drainage problems are associated with major or local drainage. For the purposes of the NSW Floodplain Management Manual, major drainage involves:

- The floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once the system capacity is exceeded; and/or
- Water depths generally in excess of 0.3m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or
- Major overland flow paths through developed areas outside of defined drainage reserves; and/or
- The potential to affect a number of buildings along the major flow path.

Mathematical/computer models
The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

Minor, moderate and major flooding
Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood.

Minor flooding
Causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to flood.

Moderate flooding
Low-lying areas are inundated requiring the removal of stock and or the evacuation of some houses. Main traffic routes may be covered.

Major flooding
Appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

Modification measures
Measures that modify either the flood, the property or the response to flooding.

Peak discharge
The maximum discharge occurring during a flood event.

Probable maximum flood (PMF)
The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with the PMF should be addressed in a floodplain risk management study.

Probable maximum precipitation (PMP)
The greatest depth of precipitation for a given duration meteorologically possible over a given size of storm area at a particular location at a particular time of the year, with no allowance made for long term climatic trends (World Meteorological Organisation, 1986). It is the primary input to the estimation of the probable maximum flood.

Probability
A statistical measure of the expected chance of flooding. (see annual exceedance probability).

Runoff
The amount of rainfall that actually ends up as stream flow, also known as rainfall excess.

Stage
Equivalent to 'water level'. Both are measured with reference to a specified datum.

Stage hydrograph
A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.

Survey plan
A plan prepared by a registered surveyor.

Topography
A surface which defines the ground level of a chosen area.

Triangulated Irregular Network (TIN)
A triangulated irregular network (TIN) is a digital data structure used in a geographic information system (GIS) for the representation of a surface. A TIN is a vector based representation of the physical land surface or sea bottom, made up of irregularly distributed nodes and lines with three dimensional coordinates (x,y, and z) that are arranged in a network of non-overlapping triangles

Water surface profile
A graph showing the flood stage at any given location along a water course at a particular time.