Rainfall and Flooding of the “Pasha Bulker” Storm, Newcastle, June 2007

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ABSTRACT

The storm that occurred in Newcastle on Friday June 8th 2007 caused wide-spread damage throughout the Newcastle and Lake Macquarie Region (c. $1.35b). It is estimated that some 5000 cars were written off and approximately 10,000 to 15,000 properties were inundated within the Newcastle LGA alone, of which 1,000 – 2,000 received over floor flooding. This paper quantifies the rainfall that occurred during this storm, and describes the flash flooding and resulting damage that occurred within the Newcastle area.

Hunter Water Corporation maintains a comprehensive set of pluviographs within the Lower Hunter region that was able to capture the spatial variability and temporal dynamics of the storm. Analysis of 18 operational pluviographs located in the Newcastle/Lake Macquarie region showed that over the region the highest intensity rainfall occurred from 3:00pm to 8:00pm, and was concentrated in the southern Newcastle/northern Lake Macquarie area. The single operational gauge with the highest intensity was Croudace Bay, which recorded 155 mm between 4pm and 6pm. Comparison to the intensity frequency duration information from Australia Rainfall and Runoff (IEAust,1987) revealed that, in general, the six and twelve hour rainfall durations had the highest intensity. For the six hour duration, seven gauges recorded rainfall that exceeded the 100 year ARI event provided by ARR, in some cases by up to 63%. Other gauges, such as BOM’s gauge at Nobby’s Head had rainfall depths 10% higher than the 1 in 100 year event. This highlights the spatial variability of rainfall over relatively short distances for extreme rainfall events.

Flooding was also highly variable across the Newcastle area, and as expected, areas most affected by flooding corresponded with areas of highest recorded rainfall. Comparison of actual flood information with probabilistic flood models suggest that in some areas, the resulting flood had an indicative recurrence probability of 1 in 100 years. Given the steep nature of the upper catchment areas, flooding within most Newcastle suburbs lasted less than one hour. Flood depths and velocities across overland flowpaths were high, and caused considerable traffic chaos as the event coincided with a Friday afternoon peak hour. Thousands of cars were left abandoned within the floodwaters.

In some areas, such as Newcastle West, flooding was exacerbated by significant blockages within the stormwater drainage system. Many smaller culverts were blocked by vehicles washed into the open drains, while in Newcastle West, shipping containers blocked the main drainage channel. The Newcastle flood has highlighted the need to consider blockage of culverts during significant flood events. This mirrors the experience of other major urban floods, such as Wollongong in 1998.

INTRODUCTION
Like the ‘Sygna’ storm of May 1974, the storms that struck the NSW central coast and Hunter regions over the Queens birthday long weekend in June 2007 are now affectionately known as the ‘Pasha Bulker’ storms, as they resulted in the grounding of the bulk ore carrier *Pasha Bulker* on Nobby’s Beach at Newcastle. The storms were caused by an East Coast Low weather system, which delivered intense rainfall of various peaks throughout Friday 8th June, as well as gale force winds (peaking at 125km/hr at Nobby’s Head, refer Figure 1), and large ocean swell ($H_{\text{max}} = 14.13$ m, refer Figure 2).

![Figure 1 Wind Speed, Nobbys Head, reproduced from BOM data.](image1)

![Figure 2 Wave data, from NSW Department of Commerce's Manly Hydraulics Laboratory on behalf of NSW Department of Environment and Climate Change.](image2)

The East Coast Low system developed out of a pre-existing low pressure trough situated over the northern Tasman Sea. The trough was delivering a humid air stream from the northeast to southeast across north eastern NSW, and by Thursday morning, a weak low pressure system had developed off the coast of Coffs Harbour. Other factors then contributed to strengthen this system including: a high pressure
system moving east from the Great Australian Bight through Bass Strait and strengthening over the southern Tasman Sea, which subsequently strengthened the flow of humid air moving easterly across eastern NSW; an extremely cold pool of air in the upper atmosphere associated with a north westerly jet stream across northern NSW, which reached the east coast on Friday; and above average sea surface temperatures, of strongest east to west gradient directly off Newcastle (J. James, BOM, pers. comm., 2007).

A continuous line of thunderstorms moved onshore directly across southern Newcastle and northern Lake Macquarie suburbs between 3.30 and 7.30pm. The thunderstorms delivered large amounts of rainfall in a short duration, causing flash flooding in these areas.

RAINFALL BEHAVIOUR

Hunter Water Corporation (HWC) maintains a comprehensive set of pluviographs within the Lower Hunter region that was able to capture the spatial variability and temporal dynamics of the Pasha Bulker storm event. Analysis of this pluviograph data revealed that the majority of the rainfall occurred in the Newcastle/Lake Macquarie Region and hence the 18 operational gauges from this region were subject to further analysis. Figure 3 shows the 24 hour rainfall total for the period from midnight Thursday 6th June to midnight Friday 7th June and highlights the spatial variability of rainfall in this large storm event. The highest rainfall occurred in southern Newcastle (Merewether/Adamstown Heights) and extended south to Northern Lake Macquarie (Redhead/Croudace Bay/Belmont), with three gauges recording over 300 mm. In comparison, in the northern suburbs of Newcastle, 24 hour rainfall totals were of the order of 200 mm. Analysis of the temporal dynamics of the storm showed that a short thunderstorm occurred around 12:00pm, while the majority of the rainfall occurred between 3:00pm and 8:00pm. The highest recorded intensity rainfall was at Croudace Bay, with a rainfall of 155 mm occurring over the period 4pm to 6pm. It is possible that even higher intensity rainfall occurred at other nearby locations (eg Whitebridge), but was not captured by any operational pluviographs. The spatial and temporal rainfall pattern is consistent with the weather radar (J. James, BOM, pers. comm., 2007).

Figure 4 compares the maximum rainfall depths for all operational HWC raingauges, at durations of 1,3,6,12 and 24 hour to the rainfall depths from Australian Rainfall and Runoff (IEAust, 1987) for average recurrence intervals (ARI) ranging from 1 to 100 years. At the 1 hour duration, only one gauge exceeded the 100 year ARI event. At the 3,6, 12 and 24 hour durations, however, 6, 9, 10 and 6 gauges exceeded the 100 year ARI event, respectively. This illustrates that the 6-12 hr duration was the maximum rainfall intensity. Figure 5 shows the maximum rainfall depths for each of the HWC gauges illustrated in Figure 3 for the six hour duration. Seven gauges exceeded the 100 year ARI event, some by up to 63%. The majority of these were located in the Southern Newcastle/Northern Lake Macquarie Area. Three gauges in the Newcastle Metropolitan area exceeded the 100 year ARI event, while the remaining five were below the 100 year ARI.
Figure 3 24 hour rainfall total for Friday 7th June. Scale on right is rainfall in millimetres and an X indicates that there was no data available for the pluviograph.

Figure 4. Comparison of Max rainfall depths for HWC raingauges for durations 1,3,6,12 and 24hrs and IFD Curves from ARR (1987).

FLOOD BEHAVIOUR

There are a number of catchments comprising the Newcastle Metropolitan area. Cottage Creek receives runoff from the areas of Merewether, Cooks Hill, The Junction, Newcastle, Hamilton East and Newcastle West. Throsby Creek (including Styx Creek) receives runoff from New Lambton, Adamstown, Kotara, Hamilton, Hamilton North, Broadmeadow, Waratah, Lambton, Maryville, Islington, Mayfield, and Georgetown. The suburbs of Wallsend, Rankin Park and Elermore Vale drain to Ironbark Creek, while Jesmond and Birmingham Gardens drain to Dark Creek. These latter two creeks drain to Hexham Swamp, before discharging into the South Arm of the Hunter River, while the former two creeks discharge directly to Newcastle Harbour.
The drainage system of the Newcastle Metropolitan area is characterised by a piped culvert system within the upper (steeper) catchment and open, concrete-lined trapezoidal channels in the lower (flatter) catchment. The persistent and intense rainfall over the catchments, and in particular along the ridge that delineates the Hunter catchment from the Lake Macquarie catchment, quickly exceeded the capacity of the piped stormwater system resulting in extensive overland flow. The intensity of the rain combined with the highly responsive nature of the catchment (given the steep topography and largely impermeable land surface) meant that floodwaters within channels, and indeed in overland floodways and storage areas, rose very rapidly – in the order of 30 to 45 minutes. Peak flood levels lasted just 15 to 30 minutes, before the floodwaters mostly receded as quickly as they rose. The rapid nature of the flooding was a critical factor in the ensuing problems, as the event coincided with peak hour afternoon traffic, hampering rescue and management efforts.

Overland flowpaths conveyed a substantial proportion of flood flows. Many of these flowpaths were along roadways, however, some were directed through private property, leading to structural damage of private infrastructure and undermining of some building foundations. Impediments to overland flow had a significant impact on flood behaviour. For example, flows crossing major roads were diverted by high median strips, redirecting flood waters down the road instead of back into the stormwater drain. The impact of solid colorbond fences across overland flowpaths was also significant. Sudden failure of such fences was reported to cause local surges in floodwater, contributing to the speed of ingress into some areas.

Local depressions within the topography resulted in areas of substantial flood inundation depth. Some of these areas, which experienced flood depths of up to 1.8 metres, were worsened by local embankments across the floodplain (eg rail corridor) that provide for only limited discharge through culverts. The whole suburb of Hamilton North was particularly affected, as it became a localised flood storage area. Flooding in this area well exceeded perceptions of flood susceptibility held by the community.
Inundation across the whole Newcastle metropolitan area was significant, with few suburbs spared. Approximately 10,000 – 15,000 properties are estimated to have been affected, with between 1,000 and 2,000 properties experiencing over-floor flooding. The commercial district of Wallsend recorded flooding of up to 1.5m over the floors, while many residential areas had flooding over the floors greater than 800mm (some even more than 1 metre). Thousands more properties were flooded to just below their floors, suggesting that had the event been slightly larger, the damage bill would have been significantly more. The Newcastle metropolitan area was fortunate in this regard, as the highest recorded intensity rainfall occurred just 5 kilometres to the south, within the northern Lake Macquarie catchment.

**FLOOD PROBABILITY**

Newcastle City Council is in the process of developing a Floodplain Management Plan across its whole LGA. Predictive flood models have been developed for the major catchments, including one model that covers the whole Cottage Creek, Throsby Creek and Newcastle CBD areas (BMT WBM, in prep). Ironically, preliminary 100yr ARI design simulations for this model were completed two days prior to the event. The match between predicted model results and the actual extents of flooding were uncanny. Although there were a few areas of discrepancy, the similarity suggests that the flood had a probability of occurrence of approximately 1 in 100 years (based on current IFD relationships, as presented in Australian Rainfall and Runoff, IEAust, 1987). As discussed above, rainfall probabilities were variable across the Newcastle Metropolitan area; some areas were well above a 100yr ARI intensity, while other areas were below. Therefore, once the rainfall across the whole catchment was combined, the probability of the resulting flood was approximately 100yr ARI, based on currently available design rainfalls. Subject to resources being made available, Newcastle Council intend to commission a review of design rainfalls for Newcastle incorporating post - ARR(1987) rainfall data.

**CHANNEL BLOCKAGES**

One of the main differences between the predicted 100yr ARI model results and the actual flood levels could be explained by the local influences of blockages within the stormwater channels. Substantial channel blockage was reported as a result of storm debris (the combination of gale force winds and rain resulted in significant tree damage), recyclable and garbage wheelie bins, colorbond fencing panels, and even cars (refer Figure 6). The most substantial blockage, however, occurred at the downstream end of Cottage Creek, wherein shipping containers from an adjacent construction site had become lodged within the culverts under the rail embankment. With the assistance of the computer model, the impact of this particular blockage was shown to be in the order of 1 metre vertically. The consequence was widespread flooding through the Newcastle West business area, and backwater flooding along the Cottage Creek drainage system (including additional inundation of more than 500mm through Marketown Shopping Centre) (refer Figure 7). Unlike most other areas of Newcastle, this inundation persisted for hours following the event, as the culvert blockage inhibited post-flood drainage.

Blockage is becoming an increasingly topical design consideration for flooding. This has primarily manifest following major urban flooding in Coffs Harbour (1996) and Wollongong (1998). Many Councils are now adopting ‘blockage’ policies to ensure that this particular risk is considered for future development. Worst case flooding does not necessarily result from assuming all culverts are 100% blocked. In fact,
worst case flooding generally occurs when a combination of blockage factors are adopted (eg low percentages of blockage in the upper catchment and high percentages in the lower catchment).

Figure 6 Cars lodged within the Beaumont St drain, inhibiting culvert flow

Figure 7 Predicted impact of blockage in Cottage Creek (red shading shows additional area inundated when rail culvert is fully blocked). Inset: shipping container in Cottage Creek

COMMUNITY RESPONSES AND REACTIONS

Discussions with community members during the weeks following the flood revealed some interesting points that are worth considering in the context of future flood management:

- Vehicles (mostly four-wheel drives) travelling through floodwaters created sizable wake (bow waves), up to 0.5m high. These waves propagated into private properties and exacerbated flood damage (in some instances, resulting in above floor inundation that otherwise would not have been affected).
• Virtually everyone consulted claimed the flooding of their property was the result of blocked drains, irrespective of the size of the drain or its likely capacity to carry the extreme volumes of rainfall received. The broader community therefore believe that Council and Hunter Water are to blame for the flooding.

• Many people believed that a king high tide was responsible for floodwaters reaching such an unprecedented depth. In reality, the peak rainfall occurred during a neap low tide. Flooding would potentially have been worse had the event occurred during the prior week or the following week, coinciding with spring tides.

• A number of people experienced depression and anxiety over the flood, particularly over the tenuous nature of whether or not insurance would cover personal damage.

• Many people were forced to evacuate their homes and seek alternative accommodation, some for extended periods of time.

• Some brand new developments (and even some still under construction), built in accordance with Council’s flood requirements, experienced over-floor flooding of, in some cases, up to 300mm.

• The lack of knowledge and appreciation of flood behaviour meant that many people placed themselves at unnecessary risk by driving or wading through fast flowing floodwaters. Unfortunately one life was lost in Newcastle when a man was washed into an open drain. Anecdotes and many ‘close call’ stories from the community suggest that it was a miracle that more lives were not lost. A further eight people died across the Hunter and the Central Coast during the Pasha Bulker storm.

TAKE HOME MESSAGES

The major event flooding in Newcastle during June 2007 provides an opportunity to examine the impacts of flash flooding within a heavily urbanised catchment. Risks associated with flooding can potentially be exacerbated by:

• Obstructions to natural overland flowpaths, including large embankments (eg rail lines), smaller bunds (eg road median strips, and even just a road camber), solid panel fences, and buildings.

• Blockage of the drainage system; many items can become mobilised during flooding (especially when it coincides with poor weather / strong winds etc), ranging from wheelie bins to vehicles to shipping containers. These can become lodged within culverts and other flow constrictions.

• Vehicles travelling through floodwaters creating bow waves on top of flood levels, and hamper post-flood recovery efforts.

• A lack of flood education and awareness resulting in poor decision-making by the community that places lives and property at unnecessary risk.

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REFERENCES

Institution of Engineers (1987) Australian Rainfall and Runoff (AR&R)