Flood Warning on 7th and 8th November 2005

Flood Prediction, Accuracy and Warning Effectiveness

Chris Wright and Linton Johnston
Engineering Hydrologists, Bureau of Meteorology, SA Regional Office Flood Warning Section

Flood Description

Floods that occurred in early November 2005, resulted from heavy rain that fell steadily over already-wet catchments, mainly in the Mt Lofty area. The major reservoirs were full at the start, as were the many hundreds of small dams in the hills.

Rainfall amounts have been shown on various maps and tables by Andrew Watson. Over the city rainfalls were not critical, and in general the city stormwater drainage coped well with the flows. Keswick Creek and its tributaries are mostly urbanised and did not flood, nor was there flooding at the Patawalonga.

Figure 1 shows the estimated flood intensities in critical catchments. The map shows the location of floods and indicates the estimated Average Recurrence Intervals. It is notable that much of Adelaide was not affected by this event, but this does not mean (as has been suggested) that the areas within the city, that were not affected in November, can be considered free of flood risk. It was fortunate that although there were major falls of rain, they were concentrated on the upland forested areas which helped to slow the runoff. Also the rainfall intensities were relatively low. Rainfalls recorded over the city were unexceptional.

The smaller catchments around Mt Lofty were in major flood, with maximum flood intensities 50 to 100-year ARI being on Aldgate Creek, First Creek-Waterfall Gully, Third Creek and Cox Creek. However once the flood flows reached the urban areas the flows were generally attenuated and contained by the drainage system.

The table below gives the rainfall intensity analysis for Ashton, close to Mt Lofty. Clearly the maximum recurrence intervals, 20 to 50 Year, were from 6 hours to 48hours, while the shorter rainfall bursts did not exceed 5 Year ARI.

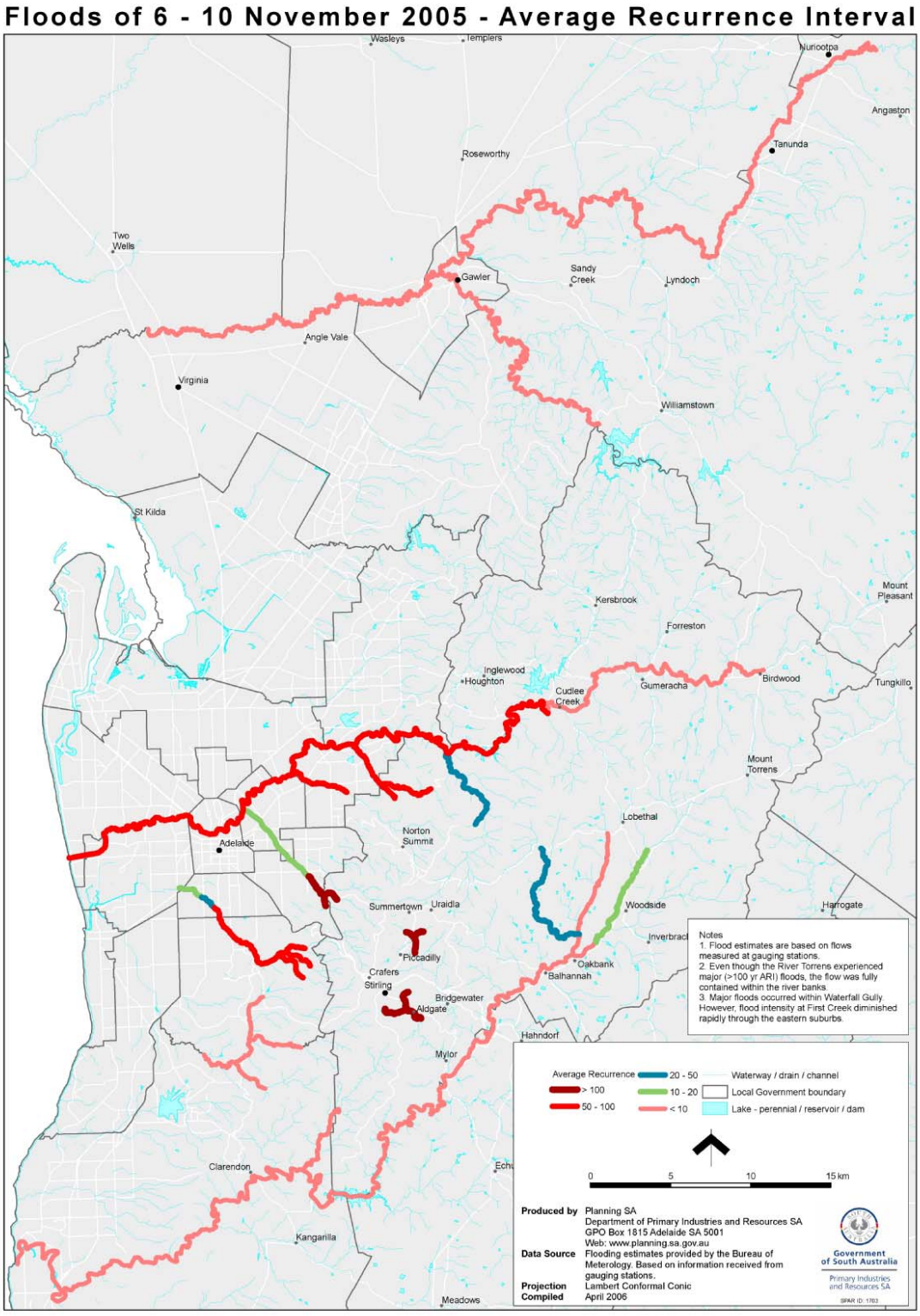
Average Recurrence Interval for
Station: 02386700 ASHTON_[023867:00:RN:ERTS]
Date: Wed Nov 9 06:23:57 2005

Analysis of the rainfall for the 68 hours to Wed Nov 9 05:49:08 2005

Rain	Period	Time	Date	ARI
3mm in	5 mins	ending at 19:19:45	07/11/2005	< 1 Year
4mm in	6 mins	ending at 19:20:45	07/11/2005	1 Year
6mm in	10 mins	ending at 19:24:45	07/11/2005	1 Year
10mm in	20 mins	ending at 19:34:45	07/11/2005	1-2 Year
13mm in	30 mins	ending at 19:44:41	07/11/2005	1-2 Year
20mm in	60 mins	ending at 19:34:46	07/11/2005	2-5 Year
31mm in	2 hours	ending at 20:14:18	07/11/2005	2-5 Year
40mm in	3 hours	ending at 20:11:00	07/11/2005	5-10 Year
74mm in	**6** hours	ending at 23:02:43	07/11/2005	**20-50 Year**
92mm in	12 hours	ending at 03:43:49	08/11/2005	20-50 Year
122mm in	**24** hours	ending at 00:39:57	08/11/2005	**20-50 Year**
150mm in	48 hours	ending at 12:19:00	08/11/2005	20-50 Year

Table: 1 Maximum Rainfall intensity analysis for Ashton

Figure1


Floods of 6 - 10 November 2005 - Average Recurrence Interval
Wasleys
Templers
Nuriootpa
Angaston
Tanunda
Roseworthy
Two Wells
Gawler
Sandy Creek
Lyndoch
Angle Vale
Virginia
Williamstown
St Kilda
Kersbrook
Mount Pleasant
Forreston
Inglewood
Houghton
Cudlee Creek
Gumeracha
Birdwood
Tungkillo
Mount Torrens
Lobethal
Norton Summit
Adelaide
Summertown
Uraidla
Woodside
Harrogate
Inverbrack
Piccadilly
Oakbank
Crafers
Stirling
Balhannah
Bridgewater
Aldgate
Hahndorf
Mylor
Clarendon
Kangarilla
Meadows
Notes
1. Flood estimates are based on flows measured at gauging stations.
2. Even though the River Torrens experienced major (>100 yr ARI) floods, the flow was fully contained within the river banks.
3. Major floods occurred within Waterfall Gully. However, flood intensity at First Creek diminished rapidly through the eastern suburbs.
Average Recurrence
> 100
50 - 100
20 - 50
10 - 20
< 10
Waterway / drain / channel
Local Government boundary
Lake - perennial / reservoir / dam
0
5
10
15 km
Produced by
Planning SA
Department of Primary Industries and Resources SA
GPO Box 1815 Adelaide SA 5001
Web: www.planning.sa.gov.au
Data Source
Flooding estimates provided by the Bureau of Meterology. Based on information received from gauging stations.
Projection
Lambert Conformal Conic
Compiled
April 2006
Government of South Australia
Primary Industries and Resources SA

Brownhill Creek and Sturt Creek were in flood, with a number of suburban properties affected, particularly in the upper reaches. The Patawalonga Lake did not flood, primarily because the tide heights were not particularly high.

The Gawler area suffered flooding at Nuriootpa, and Gawler; and at Virginia where the flood levees were breeched resulting in flood flows across the floodplain to the south.

The Upper Torrens (affecting Mt Pleasant, Birdwood and Cudlee Creek) produced Minor flooding. Further downstream the discharge rate from Kangaroo Creek dam spillway was high. While through Adelaide the River Torrens was in Major flood, but was fully contained by its banks, thanks to channel improvements carried out in the 1980s.

The Onkaparinga catchment produced flooding in the western tributaries, and there was some flooding at Verdun. Below Mt Bold reservoir Minor flooding occurred at Noarlunga.

Bureau of Meteorology Responsibility for Flood Forecasting

Under arrangements between the Bureau of Meteorology and the SA Government, the Bureau is responsible for providing flood warnings for rivers which take 6 hours or more to flood, after the rainfall. For quick response Flash Flood situations, the Bureau is required to provide advice and support to local councils and emergency services.

Flood Forecasting Issues

The floods of 7-8 November 2005 had many similarities to the last episode of major flooding which was in October 92, in that all three of the main river catchments flooded simultaneously.

However in the years since 1992, the capabilities and resources of the Hydrology section have been strengthened. The rainfall and water level network has been expanded greatly. Flood forecast models have been developed for all of the major catchments and many of the smaller ones. We have increased our experience of the effect of rainfall and catchment behaviour. Communications links with the emergency services have been developed and strengthened. Alarms for heavy rainfall and high water level have been linked by SMS messaging to mobile phones. The Flood Watch service has also been developed. This is in effect an early warning (2 days ahead) based on weather predictions using global numerical models. Flood Watch messages indicate a high risk of flood-producing rain, but are not specific in time, location or rainfall intensity

Nevertheless the Hydrology section has only 2 permanent professional hydrology staff.

Flood activity in South Australia tends to be irregular and unpredictable, with long periods of inactivity, and then sudden times of intense activity. The potential for floods over the weekend and on Monday 7th-Tuesday 8th was anticipated by the Global Atmospheric models on the previous Friday, and Flood Watch messages were issued. Chris Wright, the Senior Hydrologist, monitored the development of the rain situation and was in the office on Sunday afternoon and in the early hours of Monday morning, in anticipation of heavy rain at that time. In fact it occurred mainly in the Barossa Valley. While this was insufficient rain to cause floods, it primed the catchment for the rain that was to occur later.

The main floods started to develop as a consequence of heavy rain late on Monday afternoon.

This was the time of peak workload when heavy rain was falling and there was potential for many catchments to flood, some very quickly and others more slowly.

The overall pattern did not really emerge until some time around midnight when Sturt Creek, Waterfall Gully and Brownhill Creek were in peak flood, while floods in the Gawler, Torrens and Onkaparinga rivers were still developing.

By the early hours of Tuesday morning, the immediate problems with the faster-responding catchments were diminishing, but at the same time the floods in the Gawler, Torrens and Onkaparinga were becoming more of a concern. This developed to maximum stress level around dawn on Tuesday morning when flood predictions for the Gawler indicated Major flooding. On the Torrens several critical gauging stations were out of order and forecasts were difficult.

On the Onkaparinga, a significant concern was Mt Bold reservoir which had filled and SA Water was about to operate the gates. The magnitude of flooding at Noarlunga is directly the consequence of the rate of release of water from Mt Bold. Fortunately there was some capacity available in the reservoir at the start of the flood, and the peak inflow was considerably attenuated.

For duty staff in the Hydrology Section, the pressure was severe. Even while off duty between shifts at home, SMS alarms were received continuously on our mobile phones and it was difficult to relax or sleep.

Around 07:00 on Tuesday morning, David Kemp from SA Department for Transport, Energy and Infrastructure came in to the Bureau of Meteorology Flood Warning office to assist. David had previously offered to assist with flood warning operations and has studied the use of the URBS models that we use for real time flood warning. He is an expert on rainfall runoff modelling in South Australia and with the support of his Department, offered to assist during flood periods. Belinda Gibson Meteorologist (PO Level 1) was seconded to Hydrology from Tuesday morning. Belinda had not worked in Hydrology Section previously, but was familiar with the forms and processes for preparing and issuing flood warnings.

Together David and Belinda continued operations for the day, checking the progress and development of floods, mainly on the Gawler, issuing warnings, answering the phone, and providing information as required. In all cases, the Duty Forecaster checked and approved the warnings before they were issued. Linton Johnston and Chris Wright returned to duties later on Tuesday afternoon.

During the period of flooding, Hydrology section staff were engaged in:

- Continuous monitoring of a developing heavy rain situation;
- Weather assessment (in consultation with Regional Forecasting Centre staff);
- Rainfall forecasting (in consultation with RFC staff);
- Flood Watch message preparation, distribution and review;
- System checking and network assessment;
- Catchment status evaluation for each catchment;
- URBS forecast model running, optimising and evaluation for the four major catchments plus Upper Sturt River (refer to the following section for details);
- Monitoring of Alarms and SMS messaging;
- Flood Warning message preparation, distribution and review;
- Numerous phone calls, providing updates and information to the emergency services and the general public;
- Logging of phone calls/decisions and discussions; and
- Reviewing and discussing issues within the Hydrology Section and with Regional Office staff

Monitoring Networks – Rainfall and Water Level
The Bureau of Meteorology together with SA Water, DWLBC and local councils has developed a network of gauging stations which report in real time to local base station computers. Table 2 gives a summary.

Table 2.	**Real Time Gauging Network**		
	BoM/Council Alert Network	SA Water Scadanet	Total
Rainfall stations	103	8	111
Water Level Stations	52	14	66

For flood warning purposes 111 rainfall sites and 66 water level sites were potentially available to provide data. However in a severe weather/storm situation, failure of some of the gauges is to be expected due to electrical, water or flood damage. For the November flood most gauges were working. The exceptions were;

- the water level gauges at Gorge Weir, Kangaroo Creek and Mt Pleasant on the River Torrens; and
- South East of Gawler on the South Para, and Gawler Junction on the Gawler.

Real time Data (that is data received and stored at the time it occurs) is held at the Bureau of Meteorology and a parallel set of data is held at each of the following local base stations:

- Clare Council offices
- Salisbury Council offices
- SES Metro South at Linton
- Gumeracha CFS
- Balhannah CFS

The data is also posted to the Bureau of Meteorology web-site, updated every hour.

Flood Prediction Tools
The real time

Forecasting of floods

Flood Warning Communication Methods
Flood Warning is only useful if the people who need to be warned receive the warning in good time and know what to do about it. Effective communication is therefore an essential part of the process. It is understood, particularly for flash flood situations that in order to achieve quick and effective response from a threatened community, it is necessary to train, educate and inform the residents that they and their properties are at risk, and to have a Flood Action Plan in place so that on the day of the flood everyone knows what to do and watch out for. This pre-flood communication was very effective at some locations, particularly with the emergency response teams (SES and councils) for Brownhill Creek and Waterfall Gully, but in the case of the general public, it is doubtful whether many of the people flooded had much prior understanding of the risk. In the case of the flooding at Virginia, the understanding of flooding may have been based on the 1992 floods when breakouts from the river occurred to the north, and Virginia was spared. People are captives of their own experience and the residents of Virginia, in November 2005, might have considered that they were not at risk of flooding, despite the publication of the flood maps which indicated that they were. Were they unwilling to believe the information that the Bureau of Meteorology provided to the effect that breakouts from the river ***would*** occur, and therefore they were at risk? The warnings were unable to specify which side of the river was the most vulnerable.

The Bureau of Meteorology used three tiers of warning during the November floods:

1. Flood Watch messages, sent to registered users only;
2. Rain and River Height Alarms, sent by SMS to specific mobile phones of key council and emergency staff
3. Flood Warning text messages sent to the Media, emergency services and councils and posted on the Internet.

Flood Watch

Our Directive says "This Flood Watch is a "heads up" for possible future flooding and is NOT a Flood Warning" The service was developed particularly for the quick response Flash Flood creeks that cause flooding in Adelaide, as a means of ensuring that emergency response staff (particularly SES, CFS, local councils and Police) are alerted to a potential flood situation. They are based on weather forecasts, and issued about 2 days ahead of an approaching weather system that the numerical models indicate will be severe enough to cause flooding within a region. At that range in time, they are necessarily imprecise, however the service is valued by the users because 'Forewarned is Forearmed' and it allows them to put staff on alert, particularly over weekends. Flood Watch messages are sent by email, therefore their greatest value is achieved if they are sent during office hours, which is standard practice. The Bureau objective is that every Major flood will be preceded by a Flood Watch.

Figure 2 Typical Flood Watch Message

DS20368
AUSTRALIAN GOVERNMENT - BUREAU OF METEOROLOGY
SOUTH AUSTRALIA REGIONAL OFFICE

FLOOD WATCH
Issued at 1:25 pm on Friday, 4 November 2005

Note: This Flood Watch is a "heads up" for possible future flooding and is NOT a Flood Warning [see note below].

There is a risk of flooding in the upper catchments of the North and South Para, Torrens and Onkaparinga River during Sunday through to midday Monday. Brownhill Creek, Sturt Creek and other creeks that run through Adelaide could also be affected.

Rain is forecast to begin early Sunday and continue through to Monday as a low pressure system passes across South Australia. Thunderstorms are expected with local heavy falls over some locations, possibly from midday Sunday.

Forecast rainfall totals from early Sunday to midday Monday are expected to be 15 to 25mm with a risk of thunderstorms producing heavier falls of 25 to 50mm, anywhere in the Adelaide and Mt Lofty ranges area.

All catchments in the Mount Lofty Ranges are saturated following recent rainfalls. The South Para Reservoir [South Para River] is very close to capacity and the Kangaroo Creek Reservoir [Torrens River] is full. The Mount Bold Reservoir [Onkaparinga River] is close to full at around 88% capacity.

For up to date information on weather forecasts and warnings, please refer to the Bureau of Meteorology web site:
http://www.bom.gov.au/weather/sa/forecasts.shtml
http://www.bom.gov.au/weather/warnings.shtml

This FLOOD WATCH will be revised as necessary.

Note: This FLOOD WATCH is intended as an aid for staff and resource planning in the lead up to a potential flood situation. In an effort to provide maximum lead time before the onset of flooding, the level of uncertainty of predictions contained in the FLOOD WATCH notices is increased. FLOOD WATCH is distributed primarily to emergency response and local government agencies. The distribution of this notice does not include media or the general public.
Please call Hydrology on 08 8366 2669 for more information [or 0417 864 341 AH].

Alarms

Rain and river height alarms are linked automatically to each of the 111 Tipping Bucket Raingauges and 55 river height stations. As the rain data comes in, the main computer checks rainfall intensity and if it exceeds 10 mm in 30 minutes, it triggers an alarm that is sent by Short Message Service (SMS) to designated mobile phones. High Water levels also trigger alarms in the same way. Typically a client would receive alerts from the raingauge sites within the area of interest.

The rainfall threshold is designed to be about the 1-in-1 Year ARI 30-minute storm burst. This was chosen because although the amount is not sufficient to cause a flood, it is an indication of relatively high intensity, which if it continues could give rise to flooding.

A typical rainfall alarm message is as follows:

> "3001-0508-xxxx: = Rain Alert from SAINT JOHNS at 2006-02-24T17:24:09:
> 10min = 10.40mm, 30min = 10.40mm, 60min = 10.40mm, 3hr = 11.80mm,
> 6hr = 16.80mm. 24hr = 19.20mm"

Note that the threshold rate of 10mm in 30 minutes has been exceeded. The rainfall amounts for other storm durations are included.

Flood Warnings

The Bureau of Meteorology issues flood warnings, using standardised text messages, distributed by Fax and Email. The warnings describe the flood location, magnitude and timing. The Bureau of Meteorology standard classifies floods as Major, Moderate or Minor. A typical warning message is given below Table 4:

I174789 dated 5 April IDS20360 AUSTRALIAN GOVERNMENT - BUREAU OF METEOROLOGY SOUTH AUSTRALIA REGIONAL OFFICE

WARNING FOR MODERATE FLOODING Issued at 4:00 am on Tuesday, 8 November 2005

1. FLOOD WARNING : North Para River Minor to Moderate flooding may affect Nuriootpa during Tuesday morning [estimated peak flow is around 60 cubic metres per second].

Flooding on Jacobs Creek is diminishing. Flooding at Yaldara is now expected to reach Moderate class [80 cumecs], by 06:00 am Tuesday, and reach Turretfield about mid-day with a peak flow of about 100 cumecs. [Gauge height 4.7 metres] Gawler Town will be affected shortly afterwards. Most low level river crossings and fords will be affected and motorists should not drive through flood waters.

South Para River; The South Para Reservoir is full and is spilling at around 100 cumecs. Moderate flooding is expected downstream and will start to affect Gawler Town later on Tuesday afternoon, mainly causing inconvenience and affecting road crossings.

Gawler River; Flows are expected to reach Moderate flood level [approx 160 cumecs] in the Gawler River downstream of the Gawler township later on Tuesday and will effect low level crossings and fords. Break-out flows may be expected around Johns Road to Port Wakefield Road and at Buckland Park some time on Wednesday

Motorists are advised to avoid low level road crossings, and are advised not to drive through flooded sections of road.

2. RAINFALL AND RIVER HEIGHT OBSERVATIONS :

Latest river height observations for TUESDAY 08/11/2005 :

Angaston [Milton Park]	2.66 m rising	at 3:54 am Tue
Angle Vale [Heaslip Road]	1.12 m falling	at 3:48 am Tue
Duckponds Creek	0.68 m steady	at 3:54 am Tue
One Tree Hill [Tenafeate Creek]	0.91 m	at 3:52 am Tue
South Para Reservoir	29.40 m steady	at 3:50 am Tue
Warren Reservoir	14.33 m rising	at 3:50 am Tue

3. WEATHER FORECAST : Showers and drizzle, easing and clearing by mid-day Tuesday.

Please refer to http://www.bom.gov.au/weather/warnings for current warnings

Table 4. Flood Warning message sent by the Bureau of Meteorology

During the November 05 flood event:

1. Flood Watches were issued on Friday, Saturday and Monday (total 3)
2. Rain and River height alarms. (More than 1500 SMS messages despatched)
3. 26 flood warnings were issued.

Performance of the Flood Forecasting and Warning Service

With reference to earlier discussions on flood warning products that were available, the following table gives a summary of their use.

	Flood Watch	SMS Alarms	Flood Warnings
Gawler River			
Nuriootpa	Yes	Yes	No
Gawler and west	Yes	Yes	Yes
Onkaparinga			
Upper Onka	Yes	Yes	Yes
Noarlunga	Yes	No	Yes
Torrens			
Upper Torrens	Yes	Yes	Yes
Lower Torrens	Yes	No	Yes
Brownhill Creek	Yes	Yes	Yes
Upper Sturt	Yes	Yes	No
Numbered Creeks	Yes	Yes	No

Table 4 Flood warning products used before and during the floods.

Brownhill Creek Alarms, Alerts and Warnings

An analysis of the SMS Alarms is given below on Figure 3

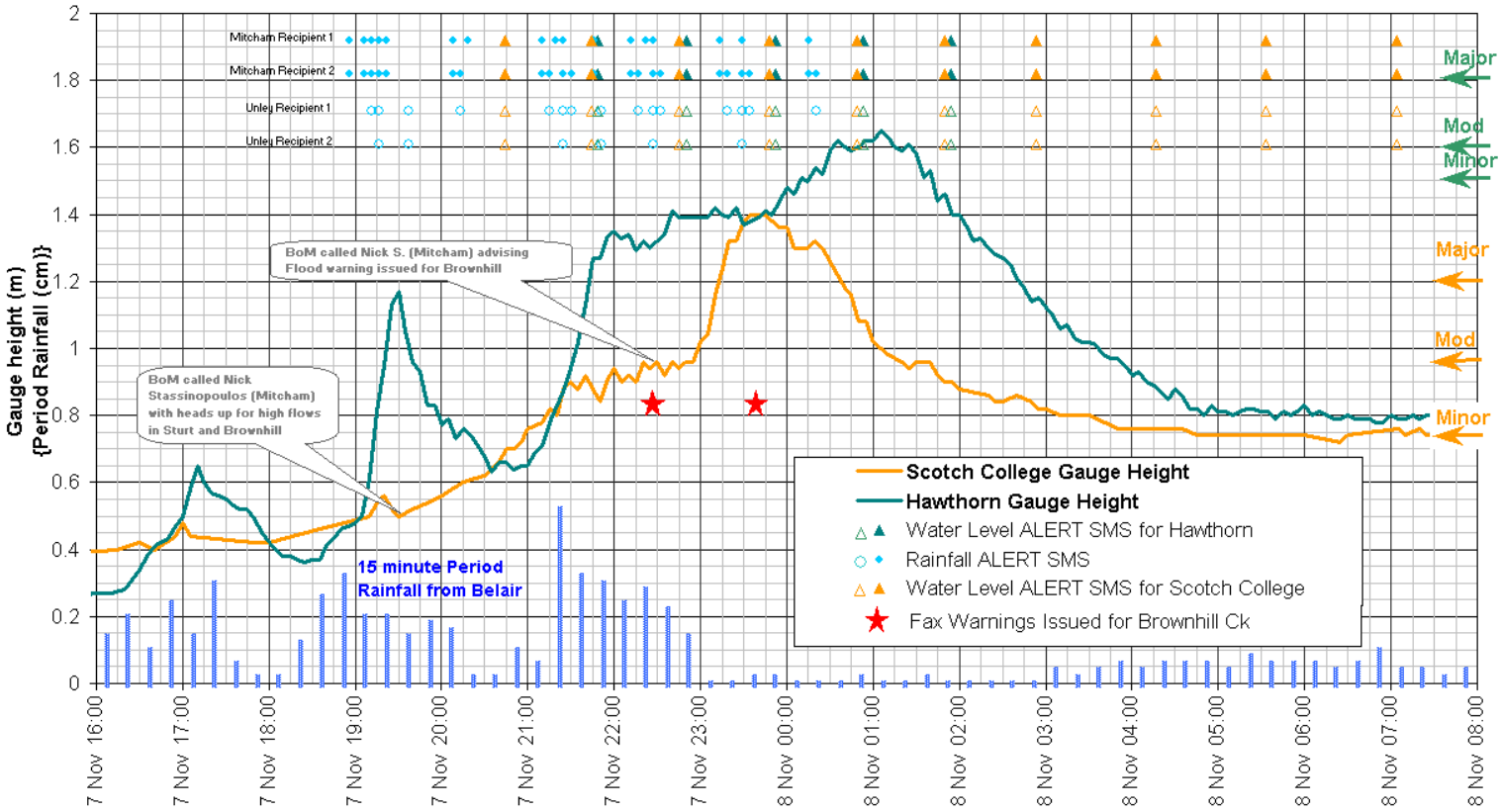


Figure 3 Flood hydrographs, Brownhill Creek Catchment, with SMS alerts sent to Unley and Mitcham Council Staff and SES unit staff

The figure shows the flood hydrographs for Brownhill Creek at Scotch College and Hawthorn (Cross Roads), and along the bottom the histogram of rainfall. The early rise in the green hydrograph, for Hawthorn, is attributed to urban runoff that flows down the Cross Road drain and enters Brownhill Creek just upstream of the bridge, subsequent flow is from the rural part of the catchment and can be seen on the Scotch College (brown) trace. It is of interest that the

earliest rainfall alarms are triggered just before 19:00, some 6 hours before the flood peak at Hawthorn. The earliest water level alarm preceded the peak at Scotch College by just under 3 hours. While the first flood warning message preceded the peak at Scotch College by about 1.5 hours. The heavy rain that produced the peak flood at Hawthorn appears to have started about 3.5 hours before, and at Scotch only 2 hours before the peak.

Gawler River Alarms, Alerts and Warnings

There is more time to prepare and issue Flood Warnings for the Gawler River. The following figure shows the modelled flood hydrograph for Gawler Junction (and the gauging stations

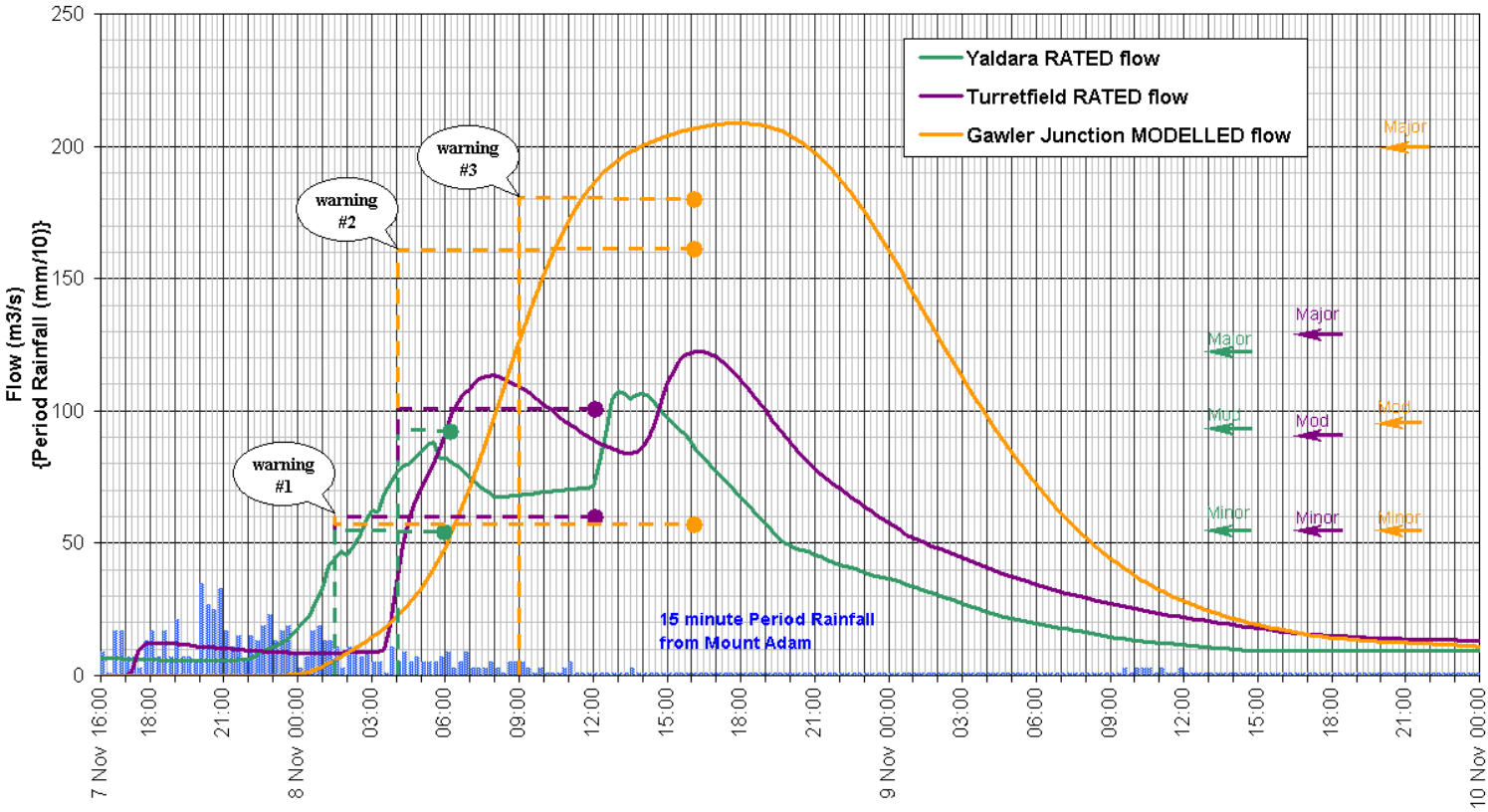


Figure 4 Flood hydrograph for the Gawler River, with rainfall information and flood Warnings.

upstream on the North Para river. The sequence of warnings is shown. The coloured dots are the forecast peak and time. The vertical dotted lines indicate when the warnings were issued. The timing of the flood peak was estimated correctly, a full 12 hours before the peak. Initially the flood estimate was for Minor flooding only, however rain that fell after the initial warning increased the magnitude of flooding. The subsequent Warnings #2 and #3 increased the forecast maximum, but as the figure shows, the peak was still underestimated. At an early stage it was clear to the flood forecasters that channel capacity in the lower Gawler would be exceeded the warning text said:

"Break-out flows may be expected around Johns Road to Port Wakefield Road and at Buckland Park some time on Wednesday"

The SES log indicates that the first reported breakout was at Johns Road at 00:30 on Wednesday morning.

Warning Effectiveness

How effective was the flood warning service? On the Gawler River there was time to prepare and distribute warnings. They were distributed widely and published in the media. It seems though that the prediction of breakouts from the main river channel may not have impacted on

the decision-makers in the SES and Police until fairly late? The warnings could not indicate which side of the river the banks were weakest and lowest. Secondly the Gawler did not break out until Wednesday morning. Flood response activities began on Monday evening, with concerns about Verdun, Noarlunga, Aldgate, Waterfall Gully and Brownhill Creek. At the same time there were concerns about the Patawalonga, which although it did not flood, was passing a large volume of water through the lake, giving rise to concerns for flood potential. Like the pieces of a jigsaw puzzle, to took time for the picture to emerge.

On Brownhill Creek and at Waterfall Gully, the Catchment Board and local councils have gone to considerable lengths to provide information to those at risk. But flooding is not a popular subject most of the time, and how many people took note of the information. On the night, how many of the people affected were aware of the risk and knew what to do about it?

The councils and SES in the Brownhill Creek area had developed a joint flood response plan, and had conducted a training exercise only a few weeks prior to the November floods. The use and value of Flood Watches and Alarms had been explained and understood, so that on the day, the emergency staff were able to respond quickly and effectively. However the comment was made that in many cases, the work that they did to assist the residents could have been done by the residents themselves, if they had had prior information about flood risk and what to do about it.

It is important to remember that no lives were lost, even though the flood waters coming down Waterfall Gully were deep, fast flowing and dangerous. There were many situations during the floods when people could have drowned. But it is not possible to determine to what extent the flood warning service, flood mapping, training and information contributed.

How could we do things better?

Each new flood event brings its own particular difficulties and challenges. Don Carroll, the designer of the URBS flood modelling package says "Know your catchment". We need to work constantly to understand the particular situations and vulnerability of the places that flood.

- On the Gawler, we knew that breakouts would occur. We did not know about the levee bank strengthening and raising that was done on the north side of the river, and therefore that the breakouts would be to the south.
- On Brownhill Creek, we knew that flooding was likely in the Scotch College-Mitcham area, but the way in which the breakouts occurred was different from the information on the flood maps.

Transmitting and distributing flood information and warnings can be improved. The suggestion has been made that Flood Watch messages should be distributed more widely, but they are only "Heads Up" notices, not warnings.

Rainfall and water level information on the web needs to be updated more frequently than hourly. Water level information would be more useful if it was presented as hydrographs. We are working on these issues.

We have good flood risk and flood hazard information which is available to the Bureau of Meteorology, the emergency services and the general public, but we need to make greater and ongoing efforts to ensure that people in risk areas are aware of it and believe it! Mitcham and Unley councils and the SES have applied for funds to appoint a Flood Risk Officer to work on this, and promote Flood Action plans for businesses and homes. The scope of this project is limited, but it is a step in the right direction.

The basic problem we are faced with is the long periods between floods, and a tendency towards group amnesia, a diminishing of understanding and awareness of risk as time goes

by. It is the task of those of us in the flood warning business to keep on reminding the planners, politicians, decision makers, financial controllers and the community at large that the risk of flood and flood damage is ongoing and every day brings us closer to the next big flood.

A full evaluation of the performance of the warnings has been given in a flood report. (Bureau of Meteorology, 2006).