A flood engineer is NOT a flood forecaster

I'm not going to lie when I was actively forecasting floods, I dreaded the day it arrived but I secretly also liked testing my skills and nerve during flood events. I have practiced and perfected my own method of flood forecasting and system builds and I think I have at least earnt the right to provide insight on the topic after managing numerous flood events.

Tropical Cyclone about to make landfall

So what does all that mean, what is a flood forecaster, what makes it different to being a flood engineer? Well that's pretty simple: flood engineers plan for hypothetical scenarios, flood forecasters get hit with reality…….hard.

It's often quite humorous in some cases I have been exposed to in my career (and others) to take advice from flood engineering consultants who have never been exposed to what a flood forecaster actually does, what they need to do it and what's required from an Emergency Management point of view (again a very misunderstood profession and skillset by many)

Background

The Flood Intelligence side of Emergency Management (EM) is a complicated, relatively new and critically important component of managing flood events. It has become its own art, own discipline and own speciality. A flood engineer is not a flood forecaster/flood intelligence officer, you can't go and grab a flood engineer from a consultancy and have them perform up to the level and skills required.

Just like EM has only recently become a serious profession so too is flood forecasting/intelligance becoming a standalone component of flooding in my opinion.

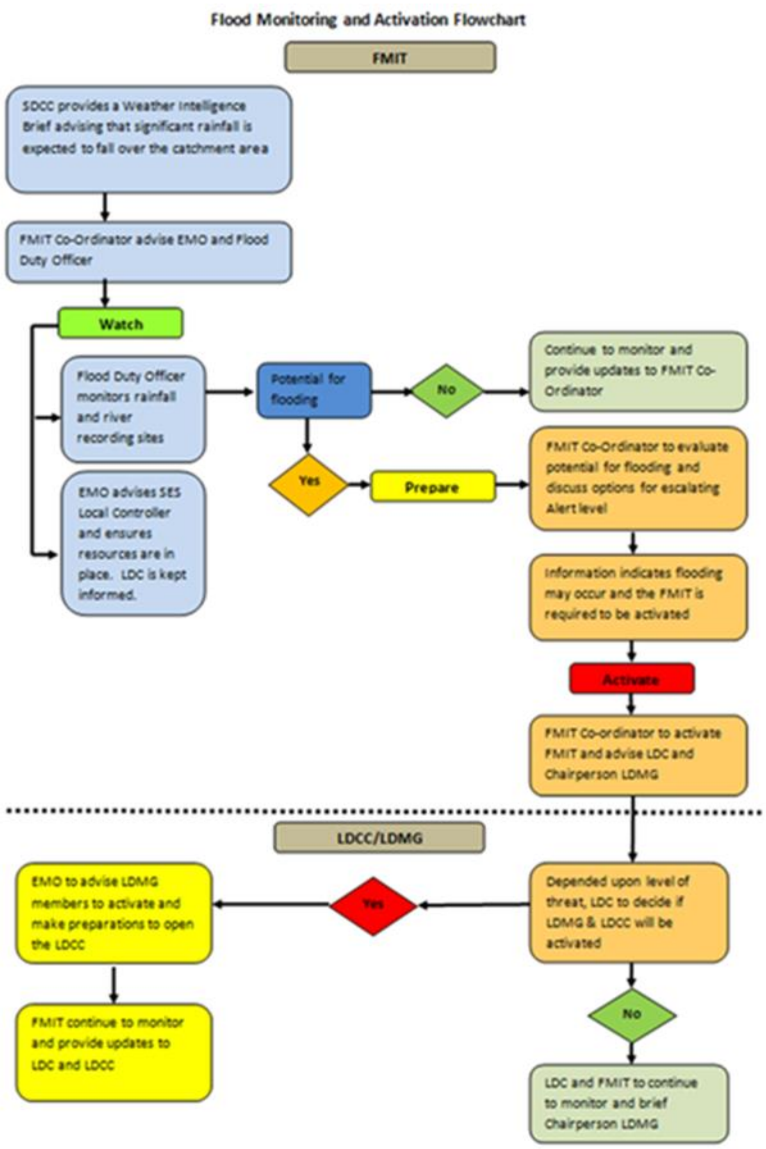
Historically informing the community revolved around the authority and community's memory. Whilst this isn't a bad thing (and I wish we could have more of that sort of thing these days) it simply does not provide enough warning to do what is necessary to prevent human fatalities and infrastructure damage and our urban catchments have become far too complicated to manage through memory.

An emergency spillway engages on a dam complicating downstream flood impact

Structure and activation

Flood intelligence cells (FIC's) are a critical component of the Local Disaster Coordination Centre (LDCC). They provide the necessary intelligence for the LDCC to manage an incoming major weather event and throughout the entire process. It is critical that the activation levels and terminology be kept distinctly different in order to prevent confusion and also public panic. In the case of the LDCC levels of activation are alert, lean forward and stand up. The flood intelligence alerts I have created are watch, prepare and activate. The FIC could be activated well before the LDCC stand ups or in some cases even goes on alert. This is very important to prevent unnecessary panic within the LDCC/Local Disaster Management Group (LDMG) or within the public.

FIC's are activated by incoming major weather patterns. A Flood duty officer may be activated via a report of major weather in the regional area with a possibility of impact to the local area. This would usually be up to a week out without a lot of other people knowing about it and this would activate a "watch" stage.



A typical activation flowchart for an FIC

Following more intelligence on impact to the local area, the FIC would move to prepare. Prepare would require resources to be organised and shifts allocated, some early correspondence would begin to flow to the LDCC but no activation of the LDCC would generally occur.

The next step in criticality is activate. This indicates a serious threat is possible to the local area and the event would only be a couple of days away. Additional staff would now be bought in a shift work activated to ensure early intelligence is forthcoming. Critical correspondence would also now begin between dam owners and meteorologists etc. if required.

A dam fills to capacity reducing its potential flood mitigation ability

Images – Flood Commission of Inquiry 2011

Resourcing

A liaison to the LDCC is critical. This is to provide overviews and intelligence briefs, whereby the critical facts need to be relayed without all of the technical components within them. The liaison officer is usually the coordinator of the FIC and thus must have a working knowledge of both the FIC and emergency management components of the LDCC. This person should have built strong relationships with the Emergency Management Professionals and the key officers of the LDCC. One must always remember that the FIC is somewhat a service provider of the LDCC and is there to provide any information and intelligence requested. It operates stand alone in some regard but is also under the direction of the LDCC.

A manual with Standard Operating Procedures (SOP) is also absolutely critical. The SOP spells out EVERYTHING about how a flood event will be managed from staff, rosters, resources, instruction manuals for systems, contact numbers and so on.

Selection of staff and management of those resources in a flood intelligence cell is obviously crucial. It is important that all staff are trained operators and most of the time this can only be achieved through actual events. Staff should be gradually introduced into operating environments through basic (communication, scribing, and basic monitoring) and eventually up to the more advanced forecasting tasks. Team members require the following attributes to be successful in teams:

- Have a solid understanding and overview of the local catchments, creeks, rivers, structures and external influences to the system
- Have a basic understanding of the LDCC process and the external stakeholders required to ensure success
- Understand flooding and weather. It is not critical to have someone understand a flood model but having a basic understanding sure helps.
- Know the operating manuals, necessary systems and background information

- Most importantly, be able to cope with highly stressful situations, adapt quickly and perform under duress.

Fatigue management of staff is difficult to manage. I've seen staff lose their cool and also have anxiety/stress attacks during flood events. Obviously as above staff need to be selected carefully for their ability to cope with stress but also monitored during events for signs of elevated stress levels and coordinators need to act quickly to prevent these type of events where possible.

Rest is critical and needs to be planned early. Trained, experienced and hardened staff may be able to cope for extended shifts up to 15 hours (and this may be necessary dependant on circumstances) but it is likely that performance will suffer after 12 hours and rosters should be planned for around this time. Additionally, new staff may not cope well after normal shifts after 8 hours, however if given less strenuous tasks, shifts may be able to be extended to 12 hours. It's all about monitoring, adjusting and re-assessing team members over time. Debriefing relief staff is critical between each shift.

Getting staff to and from home is also very important to manage. Often roads can be cut during events and this elevates complexity but can be managed successfully with a forward planning roster around expected times of road closure and opening across multiple catchments (easier said than done sometimes, I've had many a race against flood levels rising to get home and had to time my morning commute back as well). Often it is safer to organise comfortable accommodation nearby particularly for staff that do not live close to work.

Rest is critical and due to the high levels of adrenaline can be extremely difficult to do successfully!!! I personally have a lot of difficulty sleeping during flood events as my mind ticks over in half sleep assessing things like intensities, catchment condition and response times when it is raining!! Patches of intense rainfall ALWAYS wake me up!! As a coordinator it is my job to ensure my staff are trained and that I can leave them to take the reins in my absence and trust them 100%. Over the years my sleep during events has gotten easier as colleagues get better at operating independently.

Tools of the trade

The actual flood forecasting systems are only part of the package. Many other components come to together to predict, monitor and manage a flood event.

Flood Forecast Systems

The method or software used to forecast the flood levels.

There are many systems out there and we will go into detail on these a bit more in future articles but here are systems from the most basic to the most complicated:

- **Past Historical references**

  Utilising information on past flood events to provide an understanding of where flood levels may get to as a relationship of rain verse height. Pre cooked maps can be used.

- **Flood gauge monitoring**

  As above but tying in flood gauge levels and mapping and potentially also inferring relationships from upstream gauges/rates of rise etc

- **Hydraulic flood extents**

  Often referred to as a “bender”. Requires multiple gauges and hydraulic surfaces (whether 1D or 2D) are used to interpolate between gauges within zones of influence areas. Levels are informed through hydrological models/rating curves. Surfaces and maps are produced and potentially also scripting used through GIS programs to provide lists of properties impacted.

- **Live Hydrology/Hydraulic interpolation**

  These models are very fast and quite accurate. The hydrology models (Rafts/Urbs etc) are run real time using rainfall products such as ADFD/Nowcast forecast models and various types of radar rainfall. The sub catchments within the hydrology models are filled by the rainfall products on each relevant time step. Losses can also be applied/modified accordingly

  Rating curves are constructed within both hydrology and hydraulic models at strategic locations (either real or ghost gauges around significant HGL change). Levels are then interpolated between the hydraulic model library and an extent produced.

- **Live GPU Hydraulic Models**

  Can still be a combination of hydrology/hydraulics but direct rainfall can also be used to inform hydrology.

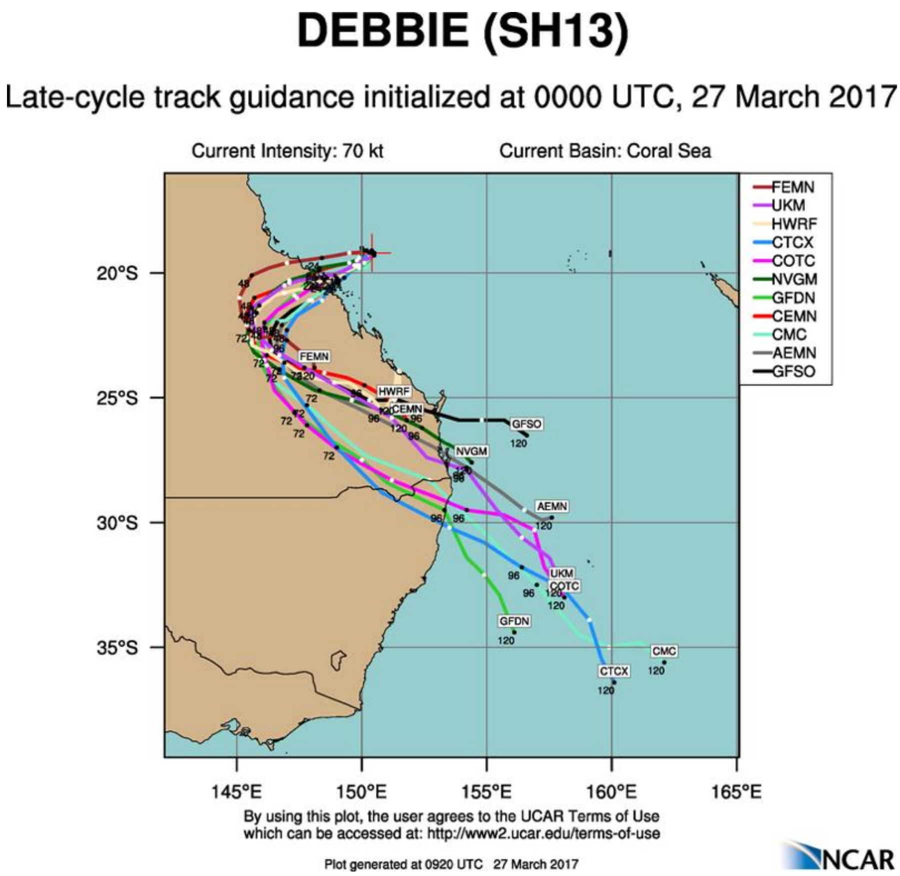
There are pros and cons of all methods. At this point in time live GPU 2D hydraulic models are still a little too slow even though they are often pitched as being fast……not fast enough. In my opinion models need to be able to be run in less than 1 hour in order to provide information on demand and frequent updates to the LDCC. In the near future this method will however be the most popular as computing power increases and in fact it’s upon us right now with the ability to run large banks of GPU’s. In future articles, I intend to delve into system types a little more.

The best balance of speed and accuracy right now are the live hydrology models. A cautionary note however that a lot of additional effort and knowledge required to transfer “standard” flood models into operational flood models.

Meteorology

Absolutely critical. This is not my area of expertise but I have a good understanding of the concepts of weather and what impacts a flood event and how, every flood forecaster must. Meteorology is varied and the models used to predict rainfall are extremely complicated. Thus a flood forecaster must have access to an expert meteorologist to provide early indications of expected weather patterns and early impact forecasts. Additionally rainfall models such as ADFD, QPF and Nowcast are obviously critical to inform the forecast models

More basic weather monitoring systems are available for forecasters through systems like Meteye on the BoM and other third party suppliers can also provide higher resolution radar imagery and modelling data for fees.



Tropical Cyclone Tracking

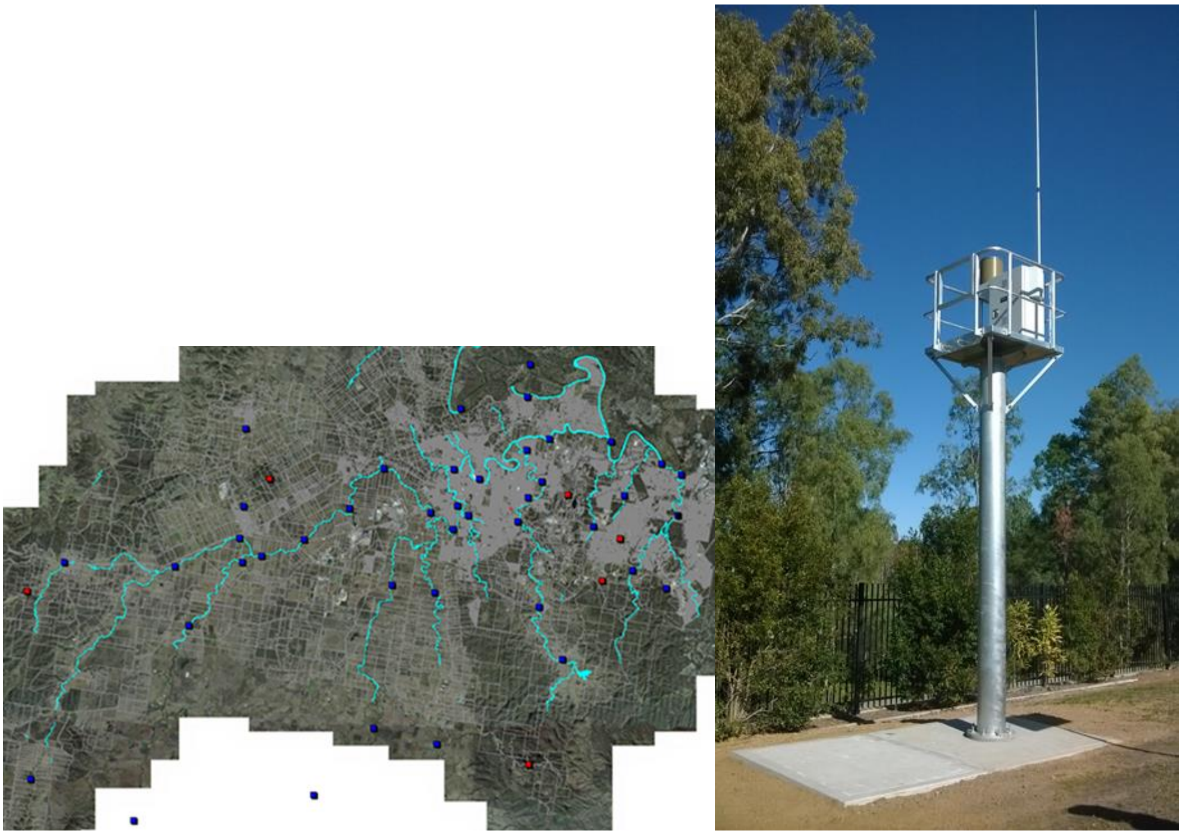
Rain and River gauges

Self-explanatory how important these are. Rain and river gauges are used to manage flooding that is occurring at the time, they can be excellent sources of public information to monitor events.

Rain gauges can be used regionally to track rainfall patterns such as intensity, duration and amount of rainfall and inform possible impacts in the near future. Stream gauges are also critical to begin to understand patterns through rivers, where peaks are coming from and how fast they are moving although this requires a detailed understanding of the catchment and hydraulic concepts.

Gauges are also very useful in providing intelligence for inundation of property and infrastructure such as bridges.

In the more advanced use of these gauges, infiltration probes can be linked to gauge locations to provide a solid understanding of catchment wetness and to inform flood forecast models accordingly. Additionally, water level gauges are critical to back calibrate rainfall losses on hydrology models. When river levels start to rise, this is the only really way to properly understand the current rainfall losses and adjust forecasting losses accordingly.



Flood gauges

Support Software

Other support software can be used to provide further intelligence such as breaking down rainfall patterns into ARI's across various sub catchments to understand early what potential magnitude floods may be possible. It is possible to do this regionally across areas outside of the local jurisdiction, understand tracking of systems and draw possible conclusions from rainfall only. This obviously does not directly correlate AEP's hydraulically (and is often used incorrectly by people that don't understand the difference) but nonetheless is powerful information to have at hand.

Putting it all together

I obviously can't write it all down but here's what I basically do before, during and after a flood event. Everyone is different but this is the way I became accustomed to:

- Follow the developed SOP religiously. Many reasons for this (including liability) but mainly to instil structure and consistency to each and every flood event. An SOP is critical
- Double and triple check systems, I get early correspondence out to the Flood intelligence team of expectations checking to see who is available and when.
- Track early. I use all my sources to understand and gain knowledge on what the weather pattern is doing and where it is likely to end up. For tropical cyclones that will often mean looking at many possible tracking maps many days out from the event. Tracking maps also provide an indication of the speed of the system which is important.

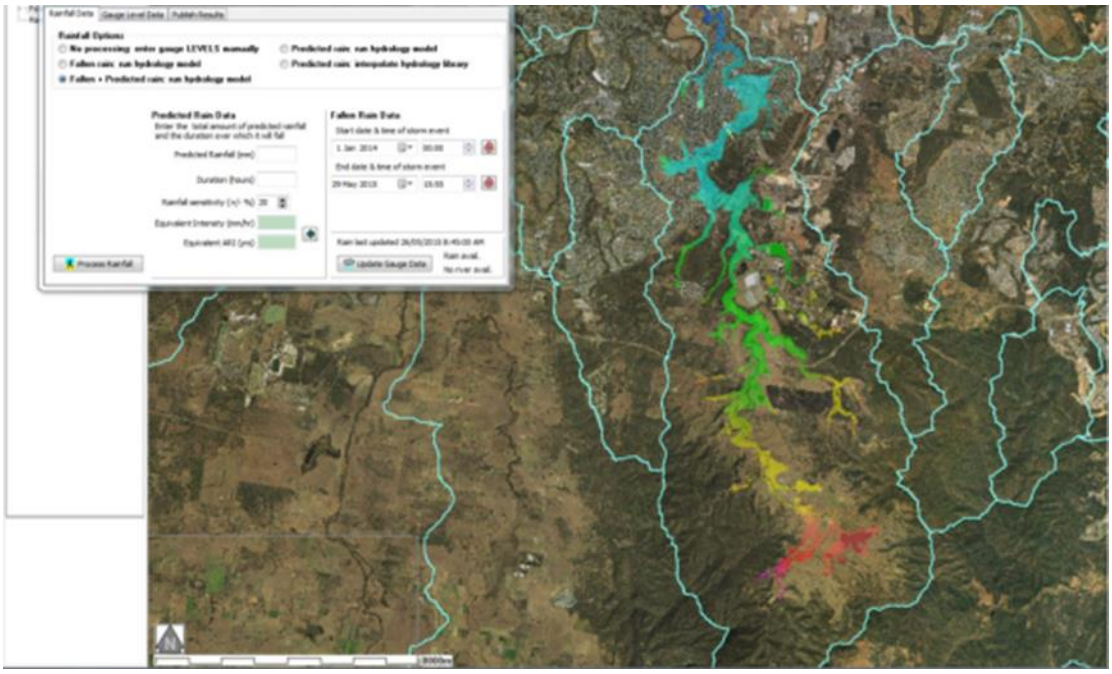
- Activate the flood duty officer and begin to use systems but also contact relevant sources such as meteorologists and dam operations engineers to understand multiple components of what will inform a flood event
- Monitor rain gauges through the regional area tracking amounts and patterns of rainfall
- Begin forecasting on major rivers up to 48 hours out utilising the BoM where necessary. This informs lower and upper threshold limits of resourcing utilising exceedance probability rainfall forecasts.
- Begin forecasting flash flood catchments up to 12 hours prior to any rain falling. This informs early indications of resourcing including the team, the LDCC and the SES

Early forecasting extents

- Begin critical early predictions on flash and riverine flooding systems only hours out before the rain arrives. If there are areas that are significantly impacted, on ground crews are sent this information early and have resources in place

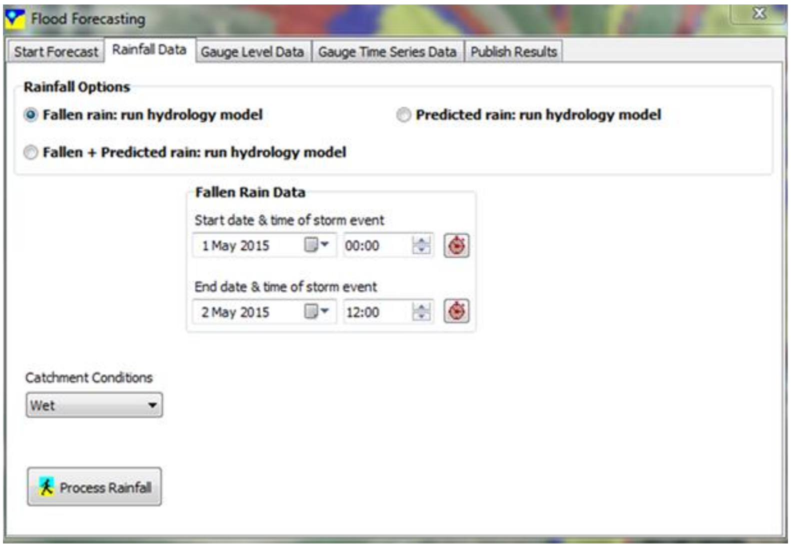
Fine tuning outputs from forecast systems

- Fine tune forecasting models as rain begins to fall. At this stage residents of impacted areas have been informed of possible issues in their area and possibly evacuation advice provided



Forecasts becoming more accurate with combo predicted and rain fallen runs

- Begin to pay a lot of attention to river and rain gauges identifying patterns, intensities and rates of rise across multiple sub catchments
- Continue to liaise with meteorologists and dam operations engineers to keep abreast of other influences
- Forecasting systems are now perform accurately, not all rain has fallen but critical areas have been identified and people evacuated. Sufficient time is still available to provide adequate warning for residents and lead time to place personnel at key locations
- Continue to issue more forecasts as all rain has fallen. Critical areas that have not evacuated may now be forcefully evacuated by the Police where imminent danger is present



Fallen rain only runs with customised rainfall loss adjustments

- Forecasts continue and the LDCC is kept informed where criticality may reduce or forecasting has been too conservative.

- Inform when levels are expected to peak with accurate timing and also where levels will begin to recede in order to open critical transport corridors.

After that, my job is largely done as levels recede. The LDCC would continue to operate through recovery phases etc.

Forecasting flood events is a fine balance between accuracy and warning times. This requires skill and experience in actual flood events to understand at what stage an LDCC requires data and how accurate it needs to be at that point in time. By providing ample warning time, accuracy suffers and waiting for too accurate data does not provide enough warning time,

The relationship between the FIC and LDCC on this component is absolutely critical

Picture some these scenarios in any bog standard flood model and what would happen (no precooked models for these ones!!):

- Rain only falls on the bottom catchment, barely any on the top. Vice versa and a multitude of patterns in between
- You get a burst of rain, a long lull and then another burst. Really got to understand your catchment critical durations and sub catchment lags for this one
- A dam starts spilling towards the end of the rain event
- Your catchment is wet, your last flood event it was dry
- Cloudbursts occur linearly along your entire catchment. A pattern of rain running up to downstream is especially dangerous
- A ex tropical cyclone partially reforms, spins and stalls over your catchment

See what I mean? Good luck trying to have these types of scenarios precooked!! This requires a lot of thinking on the fly and as a mentioned a real understanding of what you are dealing with and how it responds. Flood forecasting requires the use and reliance of a lot of complicated systems and in general some of the information feeding these systems will capture some of the above.

Although forecasting requires a thorough understanding of technology and modelling, it is also very important that a good forecaster does not have to rely on models and will know how the system will respond before the models are run. Flood events are as much about the "feel" of a flood event and your rivers and what you think is going to happen as they are running operational flood models.

Conclusion

As you can see flood forecasting is not as straight forward as you first might think, it's a complicated and highly stressful activity and one that requires actual experience through managing flood events. Authorities should be careful where they seek guidance on managing flood events if these organisations or officers have never been involved in an actual flood event.

If you need more information or assistance about managing flood events, designing systems or structuring teams and documents have a look on my website for where I can help and also check out some training that I am offering in this space.

Also look out for future part 2 – Understanding flood forecasting systems.

http://synergys.com.au