Floodplain Management: The Challenges Facing Council In An Ever Changing World

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Abstract

The floodplain management framework for Councils has been in place in NSW since the 1980s and Shoalhaven City Council has fulfilled its commitments in this regard through undertaking the full range of studies. However, the philosophy and science behind the framework is ever changing.

Climate change, and in particular sea level rise, affects all coastal councils. Councils are faced with managing these impacts and incorporating changing information into floodplain management. How successful has Shoalhaven City Council been in this regard and can it do better?

Council has collected a wealth of data from their studies on historical and design flooding, floor levels and inundation levels of property and infrastructure. However recent floods have demonstrated that what is lacking is the ability to use this information to manage the flood problem in real time. The Bureau of Meteorology, for example, does not monitor all catchments and residents may criticise Council when advice or action is not undertaken. Council seeks to improve its real time management of flooding through the use of its available data.

Design flood levels change as new technology (2D hydraulic models, ALS/LIDAR survey, geo referenced aerial photography) is developed. Council is faced with explaining these changes to the public and funding further studies to ensure that it keeps abreast of current best practice.

This paper explores the issues and problems faced by Shoalhaven City Council in addressing and adapting to these changes.

Background

Floods are a natural phenomenon that cause society significant economic and social cost including:

- Tangible direct damages to cars, houses, businesses and infrastructure;
- Tangible indirect damages such as clean up costs, loss of work, loss of trade;
- Intangible direct damages such as injury or death;
- Intangible indirect damages such as ongoing stress and worry.

The average damage bill from flooding to Australia is approximately $400 million per annum. The aim of floodplain management is to provide a set of best practice principles and guidelines for the management (and hopefully the reduction) of the risks associated with flooding. However flooding is very site specific and flooding issues vary widely between different locations. Floodplain management is also a compromise, it is a matter of trading off the economic, social, hydraulic and environmental issues, to come up with an approach which optimises the use and values of the floodplain.

Floodplains are a resource of immense value to society due to their high environmental, land use and economic qualities. In rural areas they are used for agriculture and European settlers initially settled on these areas as rivers provided

easy access. In urban areas flat areas of land are easy to construct buildings on and many urban creeks have been narrowed or filled in to increase these areas.

The early European settlers were soon faced with flooding and their initial approaches were reactive, i.e. responding to the situation but doing little to manage the problem. This latter approach is the key aspect of modern day floodplain management which is a pro-active response. This response must consider the existing and future flood problems but also the residual risk. Residual risk is the remaining risk as floodplain management cannot "solve" all flood problems.

The development of floodplain management in NSW has been forged by the magnitude and frequency of floods that have occurred. Early settlers in the Hawkesbury and Hunter Rivers experienced frequent and major floods which caused significant damage to property and agriculture as well as loss of life. Governor Macquarie's 1817 proclamation was probably the first formal floodplain management guidance in Australia. His proclamation on the 5th March 1817 stated:

"…*had the Settlers paid due Consideration to their own Interests, and to the frequent Admonitions they had received, by removing their Residences from within the Flood Marks to the TOWNSHIPS assigned for them on the HIGHLANDS, it must be confessed that the Compassion excited by their Misfortunes is mingled with Sentiments of Astonishment and Surprise that any People could found so totally insensible to their true Interests, as the Settlers have in this Instance provided themselves.*"

He then went on to say that all residences should be built above the flood marks and those who did not build above this level would receive no sympathy or compensation for their losses. This was floodplain management at its simplest.

Unfortunately this advice was not heeded, or flood intelligence was not available in all areas which has led to changes in floodplain management as ongoing development and development pressures continue in the floodplain. In the Shoalhaven Valley the 1860 and 1870 floods resulted in the relocation of the main urban centre from Terara to Nowra. The major February 1955 flood in the Hunter Valley, notably at Maitland, demonstrated that flooding could not be ignored and required action resulting in the formation of the now SES. Flooding in urban areas, more recently in Coffs Harbour (1996), North Wollongong (1998) and Newcastle (2007), has furthered the development of floodplain management in what are commonly called overland flow areas. The January 2011 Brisbane River flood is the latest major flood that has had a significant influence on floodplain management.

History of Floodplain Management in NSW

In 1984 the NSW Government introduced a merits based flood policy and in 1986 released its first Floodplain Development Manual. A revision was released in 2001, termed the Floodplain Management Manual, which incorporated updates to the prior approach. Changes to the composition of agencies and responsibilities for floodplain management in 2003 necessitated changes to the 2001 manual and an opportunity to further enhance the approach. This was achieved with the release of the 2005 Floodplain Development Manual.

An Ever Changing World

In any period of time, people have always been amazed by the recent changes to their lives and the potential changes that are likely to occur in the future. We are no different in 2016. Changes to technology (largely computers and associated equipment) means that we are able to obtain more accurate and extensive data but also the means of analysing it. However, societies greater understanding and appreciation of issues in

NSW and throughout the world (largely as a result of technology such as the internet, mobile phones, digital photographs and videos of flooding) has meant that climate change (rainfall increase, sea level rise and temperature increase), water quality, water sensitive urban design and water reuse have and will have an ongoing impact on floodplain management.

The speed of change also appears to have increased which puts increased demand on Councils to respond. In today's world there is an expectation that authorities should quickly respond to issues.

Councils however are limited in their capacity to respond by their resources such as staff, time, money, and expertise. The impact of ongoing and ever increasing rates of change and the expectation of quick implementation is that existing information is continually updated and existing project delivery is delayed with multiple changes of scope. This means that studies and plans essentially keep going and the focus on implementation is lost. This frustrates those delivering the projects as well as the communities where the projects are being conducted. It appears to the community that Council is continually planning to do something but never actually implementing anything.

Improvements To The Quality and Quantity Of Data

Our understanding of flooding fundamentally relies upon analysis of data, including rainfall temporal patterns and intensities, land survey, flood records and bathymetry. After every flood, considerable flood and rainfall data collection is undertaken. Methods of post flood data collection have changed. Methods are similar but more extensive than in the past, with questionnaires distributed and more residents contacted through various multi-media activities. Digital photos and videos, taken during an event by residents, have meant we get a real time description of the extent and magnitude of flooding. This certainly assists with our understanding of floods and allows the SES to respond at specific locations. However there is an increased burden on Councils to collect this information (immediately or if possible during the event) and analyse it. This information (if applicable) then has to be incorporated into the analysis of flooding undertaken in a flood study. Again there is pressure on Councils to fund a study to respond immediately to any required change.

After a flood Councils focus their attention on recovery, ensuring that services are re-established to a safe and working order. Because of this there are limited, if any, resources available for Councils to conduct post flood data collection. In addition to this Council staff may not have the skills required to conduct this work. Councils therefore rely on the availability of budget and appropriately skilled consultants to dispatch crews to gather this information on their behalf.

In August 2015 the Shoalhaven was hit with minor to major flooding across its entire local government area (LGA). With a number of the flood studies in these areas being 15-25 years old it was imperative that post flood data collection was conducted. Shoalhaven Council was in a position to dispatch a team of consultants to gather peak flood heights.

These floods led to the community and elected representatives calling for the revision of the adopted floodplain risk management studies and plans. This was expected to occur immediately. The benefit of being able to respond immediately is that the community is engaged. Unfortunately reviewing these documents and 10 year work programs is not a quick exercise which leads to the community support having dwindled by the time resources are available to conduct the works.

The analysis of rainfall data, particularly from continuous read gauges (pluviometers), has been one of the most significant changes in recent times. For example, the 1987 Australian Rainfall and Runoff (AR&R) design rainfall estimates were based on

approximately 7,500 daily read stations and 600 pluviometers. The recently released 2013 estimates are based on 20,000 daily read stations and 1500 pluviometers. This has significantly improved the accuracy and representativeness of intensity, frequency and duration (IFD) estimates, particularly for sub daily durations and in urban areas. A consequence of this is that flood studies have to be revised to incorporate the updated information. The outcome may be that flood extents or the number of properties inundated in a given event may change. These changes can be difficult and time consuming for Council to manage and certainly provides flood sceptics in the public arena with further ammunition.

A further complication with the 2013 IFD data is that it needs to be used with the updated temporal patterns. Whilst the theory behind the updated temporal patterns has been established, the practicality of how this can be incorporated into day to day usage by consultants, councils and other authorities has not yet been finalised.

Probably the greatest improvement in accuracy of flood extents, depths and velocities has been the use of aerial laser survey (ALS) or LiDAR survey data. Prior to approximately the year 2000, expensive cross section survey data and 1:4000 contour maps (contour spacing of 2m) were the norm for use in flood studies in NSW. However ALS provides data points (accurate to +/- 150mm on hard surfaces) at approximately 1m spacing over entire catchments. Combined with geo-referenced aerial photography this provides a very accurate description of the topography of a floodplain. All Councils now have part or complete ALS coverage for their LGA.

Whilst a very significant improvement the use of ALS introduces other issues to Councils. Comparison of ALS from different years in a catchment invariably indicates that changes to the terrain have occurred. Are these due to different accuracies of the ALS data sets or are they real changes? The answer is probably both which then requires investigation by Council. There is also pressure on Council to continually update their ALS database in order to monitor filling and to ensure flood levels are not affected.

Improvements of quality and quantity of data have led to many improvements in flood modelling and mapping in the Shoalhaven LGA. These improvements however have led to the need for ongoing data management and revision. This again takes resources away from current and future planning projects, further slowing the delivery of flood mitigation measures and works.

Technological Improvements

As with probably every industry today, improvements in technology have resulted in better and mostly cheaper outcomes. In floodplain management it is no different. Flood estimation requires computer software and hardware to solve equations which ultimately provide the flood levels and extents. The HEC-RAS software (or the prior HEC2 which was commonly used in the 1980s) uses cross sections at defined spacings and takes only minutes to run, even on 1980 computers. The later CELLS, Rubicon, Mike-11 or other similar 1 dimensional software programs, introduced in the late 1980's, still used cross sections but with added features such as storages and provided a more rigorous definition of flooding across the entire floodplain. These would take up to an hour to run.

Today with topographic detail from ALS combined with geo referenced aerial photography, TUFLOW 2 dimensional hydraulic modelling software has become the dominant industry tool. This allows discretisation of the floodplain into grids (1m in an urban catchment or 10m or greater in a rural catchment). Flow between or through buildings can be estimated with a high degree of accuracy and flood extents determined to say 1m lateral extent. With millions of grid cells to be calculated every second of the flood duration means that even with today's high speed computers the

run time is invariably in excess of 6 hours or even days with events lasting more than 24 hours. Thus using today's TUFLOW models for real time flood forecasting is rarely possible. It also means that to calibrate models or evaluate a design iteration takes a lot longer than previously.

Climate Change - Sea Level Rise

The possible impact of anthropomorphic sea level rise on floodplain management first arose in the mid 1980's. Flood models were run with sea level rise increases or sometimes rainfall intensity increases. Councils could then make their own decisions regarding whether an increase should be incorporated in flood related planning controls or not. It was only in the mid 2000's that the Intergovernmental Panel on Climate Change (IPCC) provided definitive quantitative advice on sea level rise. This resulted in the NSW Government introducing the 2009 NSW Sea Level Rise Policy which nominated a 40cms rise by the year 2050 and 90cms rise by the year 2100. This policy was definitive and adopted in Council flood studies and in most Council's flood related development controls.

Subsequently a major change in the NSW Government's advice occurred with the release of the 2012 review by the NSW Chief Scientist and Engineer. While generally supporting the understanding of the climate change issues, the review highlighted the uncertainty associated with sea level rise projections and the possibility of undertaking more regionally specific calculations. Following this review the NSW Government in 2012 repealed the 2009 NSW Sea Level Rise Policy and associated benchmarks. Instead it recommended that individual Councils could adopt a range of locally relevant projections in line with competent scientific opinion.

This 2012 decision represented a significant change in attitude and placed the onus on Councils to determine their local sea level rise. In accordance with this new approach Shoalhaven City Council (in conjunction with Eurobodalla Council) undertook such a study covering approximately 200kms of coastline. The study was undertaken by Whitehead & Associates and completed in 2014. One of the outcomes was that any difference in sea level estimates between Sydney and the study area will be minimal. This contradicts one of the outcomes of the 2012 review by the NSW Chief Scientist and Engineer. Furthermore the review supported a projection based on RCP8.5 in the most recent IPCC assessment (AR5). This projection did not differ much from other possible projections up to the year 2050. The study also recommended a planning framework for the implementation and ongoing management of climate change data and planning.

The changing sea level rise projections have led to frustration and confusion within the community and council, making it difficult to justify the use of sea level rise projections and easily implement development controls. This has led to haphazard floor levels between neighbours as floor level height requirements changed depending on when their development application was submitted. A better way of implementing change needs to be identified so that critical issues, which may affect the long-term viability of some areas, can be appropriately managed.

Sea level rise has the potential to have a devastating impact on many urban communities in the Shoalhaven coastal region. For example Greenwell Point (part of the Shoalhaven River catchment) is on land only just above the highest astronomic tide, with sea level rise large parts would be frequently inundated by higher than average high tides. In time sea level rise would make these and other communities uninhabitable, requiring either mitigation structures or population removal. Sound and timely planning measures are required to address this issue.

Unfortunately the science behind sea level rise is imprecise and interpreted differently by different organisations. This does not bode well for Councils who have to make

challenging decisions in the face of criticism from sea level rise sceptics. Changing guidelines and approaches provides fuel to these sceptics. A clear direction therefore needs to be provided by State and Federal Governments so that direction is based on scientific opinion rather than individual interpretations of scientific information at the local government level. In the case of Shoalhaven Council, the recommendations in the 2014 study were either not adopted by Council or different sea level rise projections were adopted compared to those that were recommended.

This highlights the need for strong guidance from State and Federal Government and the need for a framework for future planning which is adaptive, allowing sound planning and decision making to occur. This framework will allow continually changing information to be altered as new information comes to hand.

Climate Change - Rainfall Intensity Increase

Whilst anthropomorphic rainfall intensity increase has been mentioned in floodplain management since the 1980's it has received much less focus than the more developed sea level rise increase impact. Whilst research has been undertaken in the rainfall intensity increase field there is little definitive quantitative guidance from any recognised body. In some areas it is claimed that rainfall intensities will increase but in other areas it may decrease.

Sea level rise will likely produce a greater increase in flood level than rainfall intensity increases but the former will only affect the coastal areas. Rainfall intensity increases will affect all properties and have ramifications throughout the entire building industry (size of gutters and downpipes). It will also affect flood planning levels, on site storage requirements and many other areas.

The dilemma for Councils is that the scientific backing (provided by the IPCC for sea level rise) to support and quantify rainfall intensity increase is lacking. Thus if Councils amend their flood related development controls to include rainfall intensity increases they risk being challenged. Having said this, it may also be possible for Councils to be challenged for doing nothing. As planning for climate change in Australia is still in its infancy the future ramifications of planning for, or not planning for this change are unknown.

The Change in Flood Extent Mapping

Up until approximately the 1990s flood extent mapping and the tagging, or identification of properties subject to flood related development controls, was largely defined by a level 0.5m above the 1% AEP flood level along the main rivers of NSW. However 2 dimensional TUFLOW modelling and the use of ALS has meant that urban areas can now be modelled where there are no large creek or channel systems. This overland flow flood study approach was started in Sydney in the late 1990s but has extended to other urban areas.

The majority of local government areas in Sydney have undertaken some form of overland flow mapping which now greatly extends the number of properties subject to flood related development controls. It also has other consequences as flood impact studies have to be undertaken by developers to ensure that the construction of a larger house on a lot will not increase flood levels or divert floodwaters onto their neighbours.

This was conducted in the Shoalhaven in the Lake Wollumboola catchment. Information from the overland flow study has fed into Council's management of the stormwater network as flow paths and blockages were typically identified in and along the road/drainage networks. This has allowed a very practical use of flood information that does not typically occur in other mainstream flooding projects.

The greater emphasis placed on floods larger than the 1% AEP (notably the Probable Maximum Flood or PMF) in the 2001 Floodplain Management Manual meant that the flood extent considered by Councils increased significantly. However has the emphasis on the PMF been pushed too far? For example, it is generally accepted that new developments should not produce flood impacts in the 1% AEP event but some Councils have extended this to require no impact in the PMF.

Real Time Floodplain Management

Some form of flood warning systems have been used in NSW since at least around 1900. As technology improves so have the flood warning systems. These have advanced from simple telephone messages from upstream to automated river and rainfall gauges and to today where radar and satellite data are used. Councils also have a wealth of other data related to flooding including house floor levels - who gets inundated first and records of past floods. However what is lacking is the ability of Councils to be able to use all this knowledge in real time to manage the flood problem.

In the Shoalhaven LGA 12 Flood Studies/Floodplain Risk Management Studies have been conducted. Of these 12 catchments, only two receive flood watch/warnings from the Bureau of Meteorology. The remainder are classified as flash flood catchments and therefore do not receive any flood warnings. It therefore falls on the shoulders of Council to use its available information to undertake flood forecasting before and during an event.

This has led to a change in information provided in a Floodplain Risk Management Study. Many of the Floodplain Risk Management Studies undertaken have shown that few structural mitigation options have a beneficial impact on flooding. Land use planning and development controls, community education and the distribution of flood intelligence to the SES are the key recommendations of these plans.

Therefore current Floodplain Risk Management Studies and Plans focus on the provision of data to Council and the SES that can be used to plan for and respond to floods. This emergency management focus is moving away from information traditionally provided and is now focusing on critical information for emergency management and planning. This information is used in conjunction with water level and rainfall alerts which are sent from enviromon software (the software used to monitor Council's network of water level and rain gauges). Council also has the benefit of using waterRIDE which has the capability of using forecast rainfall in existing flood models to forecast expected flood levels. During an event this has not been tested. The question is, does this responsibility to determine peak flood levels fall on individual Councils or should the SES or the Bureau of Meteorology lead the way in this felid?

Conclusions

As data, technology and scientific opinion continue to change, so too will the Floodplain Management Process. However, for this process to remain current, it will need to adapt to the ongoing changes that feed in to this process.

The process and its outputs need to change so that data is useful for planning purposes and for the identification of mitigation measures but also for emergency planning and flood forecasting.

With a general shortage of flood engineers at the local government level, limited budget, software and time, resources of Councils will continue to be stretched. As more and more responsibility falls on councils, their resources will continue to be utilised updating and remodelling existing information rather than implementing mitigation measures and works and conducting flood emergency planning.

The community and often council officers do not understand why information is changing so often. This adds doubt to the validity of information and frustration to those planning development, wanting to complete a project or implement Council's planning and development controls. The drawn out process is leading to a disengaged community as they cannot see the value in the study process.

A framework for adaptation needs to be provided to Councils so that current challenges can be addressed and consistently implemented. Processes need to be put in place which allow Councils to easily update information in Section 149 planning certificates, flood mapping in Local Environmental Plans, and information in Development Control Plans.

Change is ongoing therefore the impacts of change are also ongoing. A focus on providing direction and tools from State and Federal Governments is required so that sound, long term, easily implemented planning and implementation can be conducted by Councils to ensure the ongoing success and implementation of the Floodplain Management framework can continue.