INTEGRATING FLOOD MODELLING AND EMERGENCY RISK ASSESSMENT: DO WE HAVE THE DATA WE NEED?

D Trebilcock[1]
[1]Department of Environment, Water and Natural Resources, Adelaide, SA
(formerly with SA Fire and Emergency Services Commission, Adelaide, SA)

Abstract

Flood modelling in Australia has evolved from being an engineering tool focused on quantification of large and extreme events to a tool for managing flood risk across the entire flow regime. This necessitates new and varied sources of input data.

Elevation and hydro-meteorological data-sets are important to understanding flood behaviour; but to understand the consequences of a flood event a range of environmental, social and economic data-sets are also required. The National Emergency Risk Assessment Guidelines (NERAG) provide a contextualised methodology for assessing the consequences of emergency events, including floods. Applying the NERAG specifically requires information on the people, economy, natural environment, public administration and the social setting of affected communities.

In Australia, responsibility for managing flood risk is shared across all levels of government, and specific arrangements vary by jurisdiction. It is inevitable that available data-sets will be spread across multiple formats, multiple systems and multiple custodians. Furthermore, each and every flood study has specific requirements—often highly localised—and draws on a diverse cross section of data. For these reasons, the idea of a national 'one-stop-shop' for flood risk modelling data is unrealistic, yet there are activities that can help promote consistent nomenclature and uniform access to data-sets.

This paper reports on a project that identified some of the key barriers, enablers, challenges and opportunities in obtaining data for flood risk modelling, and recommends some national initiatives and strategies that can assist in ensuring that the required data-sets are, and remain, accessible.

Introduction

Flooding is a natural phenomenon which can positively impact surface water and groundwater supplies, the fertility of arable land, and natural ecosystems. But flooding is also one of Australia's most destructive natural hazards, which results in fatalities, widespread property damage, economic loss and adverse social effects (RAMMS 2012a). Over the last few decades, the focus for Hydrological Engineers and floodplain managers alike has evolved from an interest primarily in large and extreme events, to managing risks across the entire flow regime. This calls for access to a broader range of environmental, social and economic data-sets than have traditionally been associated with flood modelling.

The National Work Program for Flood Mapping (NWPFM) was initiated through the Australia-New Zealand Emergency Management Committee (ANZEMC) in 2011 as a sequential series of projects to deliver:

- National guidance on flood risk mapping
- A clear understanding of the coverage and detail of existing flood maps
- Tools to improve the quality of flood maps in Australia.

As part of the NWPFM, the National Flood Risk Advisory Group (NFRAG) supported the project described in this paper to examine the availability of data required for flood risk assessment. The purpose of the project, broadly, was to:

- Review and summarise data requirements for flood modelling and flood risk assessment
- Review data-sets available from states, territories and the Commonwealth
- Identify barriers to wider collection, sharing and re-use of data-sets.

The need for the project

The *National Strategy for Disaster Resilience* (COAG 2011) promotes a resilience based approach to disaster mitigation built on shared responsibility and understanding. Underpinning this approach is a requirement for accurate information about hazards and their associated risks.

The need for the NWPFM (and this component project) arose from acknowledgement that there was a lack of consistency in the way that flood mapping was undertaken, and in the way that flood risk information was made available across the nation. Commenting on the respective roles and responsibilities of governments to provide flood risk information, the *National Guidelines for the National Flood Risk Information Program* stated that (AGD 2012, p.11):

> …the existence, quality, scope and consistency of flood maps around Australia are highly variable, differing both within States and from State to State. Flood maps can differ greatly in terms of resolution, format, reliability and information content, as well as differing in how they are used. Not all the information that exists is publically available.

Early projects in the NWPFM provided a strategic overview of flood risk management, a jurisdictional overview of flood risk management, and an analysis of end user needs. Latter projects in the NWPFM—including this project—begin to provide a framework for best practice flood risk assessment, and resolve impediments to best practice.

From the outset of this project it was recognised that the lack of consistency in flood risk information was due, in-part, to the accessibility of data and information. With every state and territory in Australia maintaining some form of flood mapping program (see for example the *Jurisdictional Stocktake*, RAMMS 2012b) it was evident that a lot of relevant data-sets were available. Some of the variability in flood risk information therefore resided in the accessibility and suitability of the underlying data-sets used to derive this information, or the way in which these data sets-sets were used. With the focus on improving accessibility and suitability, a list of barriers and enablers to improved flood risk information was proposed (Table 1).

Flood risk and flood risk assessment

Flood risk arises from human occupation of the floodplain and is a product of the hazards posed to life and property by flood events. These hazards include fast moving water, deep water, rapidly rising water and isolation from places of refuge. Flood risk may be existing (associated with current development on the floodplain), future (associated with potential development on the floodplain), or residual (the risk remaining after mitigations and controls are implemented).

Table 1 Barriers and enablers to improved flood risk information

Barriers		Enablers
• Competing priorities	**Strategic**	• Leadership; effective governance
• Missing, incomplete and out-of-date metadata • Duplication of data-sets and data sources • Obscured data sources	**Knowledge**	• Consistent, complete and current metadata • Singular and authoritative data-sets and data sources • Easily discoverable data sources
• Lack of funding for data collection and maintenance • Skills shortages	**Resources**	• Sustainable funding for data collection and maintenance • Skilled practitioners
• Missing, inconsistent and inefficient processes to obtain data	**Process**	• Clear, integrated and consistent processes to obtain data
• Limitation of currently available technology • Proliferation of differing techniques	**Tools & Techniques**	• Productivity and efficiency gains through new technology • Standard but flexible techniques
• Restrictive licencing of data • Commercial-in-confidence data	**Legal**	• Open licencing of data • 'De-identification' of data sources

Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (NFRAG 2013) outlines a best practice approach to flood risk management. This Guide stresses the importance of understanding flood behaviour as a necessary precursor to understanding and managing flood risk

A *flood study* is the tool that provides the understanding of flood behaviour. Invariably a flood study is a comprehensive technical investigation which involves the construction and calibration of one or more hydrologic or hydraulic models (flood models). These models take data on the natural and built environment as inputs and are applied (usually with extrapolation) to understanding the full range of flood behaviour within that environment; the probability of occurrence of different sized floods; and, the impacts of floods of different probabilities.

Flood risk assessment is the systematic process of identifying, analysing and evaluating flood risks, by combining knowledge of flood behaviour with knowledge of the people, infrastructure, communities and enterprises at risk. It is inherently reliant on flood studies, but a necessarily much broader activity that informs flood risk knowledge and, ultimately, management of the floodplain (Figure1). Flood risk assessment therefore has utility to emergency managers, land use planners, social planners, asset managers and environmental managers.

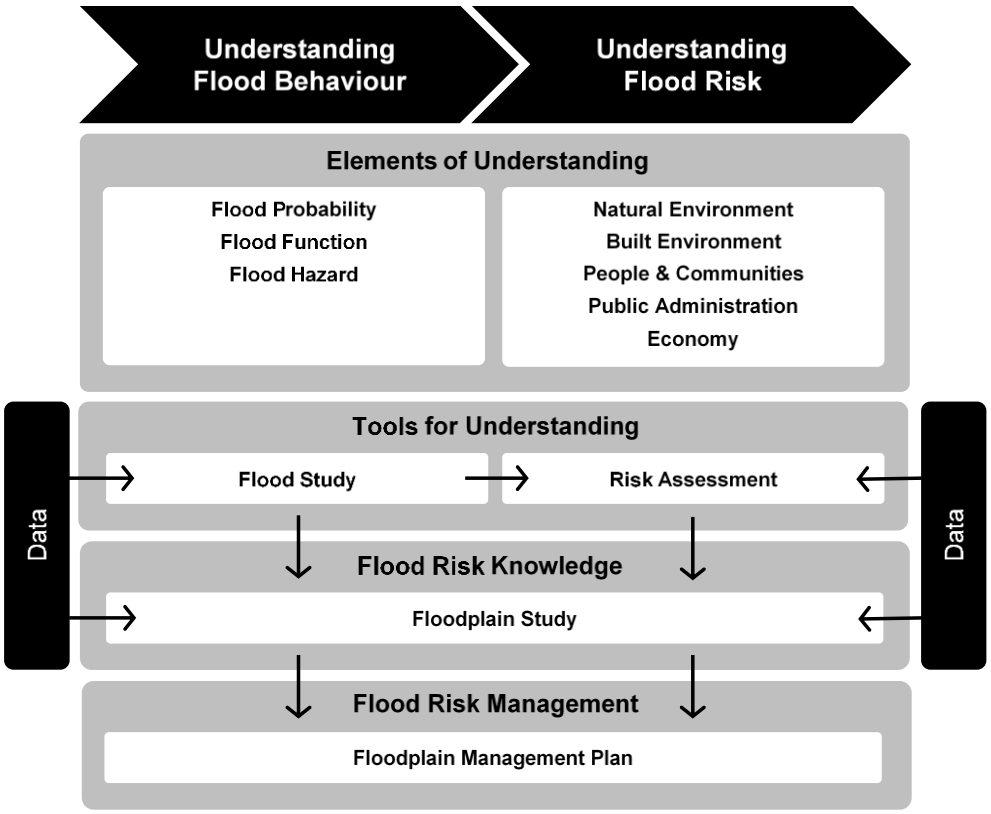

Figure 1 Flood risk assessment

Flood risk assessment considers not only the direct consequences of flood waters, but also the indirect or consequential impacts that arise, for example, from loss of service capacity, disruption of community function and psychological distress. The National Emergency Risk Assessment Guidelines (NERAG) provide a contextualised methodology to assess risks from an emergency management perspective and in a manner consistent with the Australian/New Zealand standard for risk management (AGD 2014). The NERAG is the preferred framework for flood risk assessment to enable flood hazard to be compared with other hazards in a consistent and transparent manner. The NERAG require risk consequences to be assessed in the following categories:

- People consequences—including death, injury and illness
- Economic consequences—including loss in economic activity or asset value, and impacts on sectors of industry
- Environmental consequences—including species and landscape loss, and loss of environmental value
- Public administration consequences—relating to the ability of governing bodies to continue to deliver core functions
- Social setting consequences—relating to the wellbeing and cultural identity of the community.

Data required for flood risk assessment

Floods impact both natural and built features on the floodplain, and can profoundly affect the lives of the individuals and communities who inhabit the floodplain. Flood risk assessment requires data to represent, characterise, measure and predict the interactions between these floodplain inhabitants, the natural environment and the built environment.

The data requirements for every flood study do need to be determined on a case-by-case basis. Indeed *Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* notes that "the degree of effort required, and approaches used, to understand flood behaviour will vary depending upon the complexity of the flood situation, and the information needs of government and the community to understand and manage flood risk" (NFRAG 2013, pp.2-3). Factors which do influence the data requirements of a flood study include:

- The study scope. This will vary in response to the level of flood risk, the scale of flooding and the type of flooding. As part of the NWPFM, generic briefs for 'simple' and 'complex' flood studies have been developed (NFRAG 2014).
- The catchment to be modelled, in particular the degree of urbanisation. Urban flood studies tend to require more data relating to overland flow and drainage infrastructure (Taaffe, Askew, Retallick & Babister 2014).
- Model sophistication. Data requirements vary between one-dimensional and two-dimensional models, and with the resolution of the model.

Nevertheless, the data required for flood risk assessment will tend to fall into five categories, which were reported in SAFECOM (2014a) and are summarised by way of the diagram in Figure 2. These categories loosely mirror the categories for 'consequence criteria' outlined in the NERAG (AGD, 2014, s.6.4) and are:

- The natural landscape (including the hydro-meteorological regime)
- The built landscape
- Public administration arrangements
- Social and cultural characteristics
- The economy.

Data availability, accessibility and suitability

Numerous factors influence whether a data-set is available, accessible and/or suitable for flood risk assessment (Table 2). These factors are not absolute measures and in practice, compromise is often required. An end user may have to do one or more of the following:

- Negotiate or accept less than ideal data disclosure conditions, data formats or cost
- Manipulate data-sets to improve their suitability to the flood risk assessment
- Modify the objectives of the flood risk assessment to suit the available data.

Not all of the numerous data-sets required for flood risk assessment or for a flood study are equally critical. Data gaps can often be overcome using aggregate, proxy or assumed data-sets and professional judgement. Elevation data and hydro-meteorological data, however, are of fundamental importance to flood mapping and provide the key site specific information required to carry out flood mapping. These data cannot be substituted or assumed, and where suitable data is unavailable, a significant portion of the resources of a flood study must be directed to obtaining them before proceeding further.

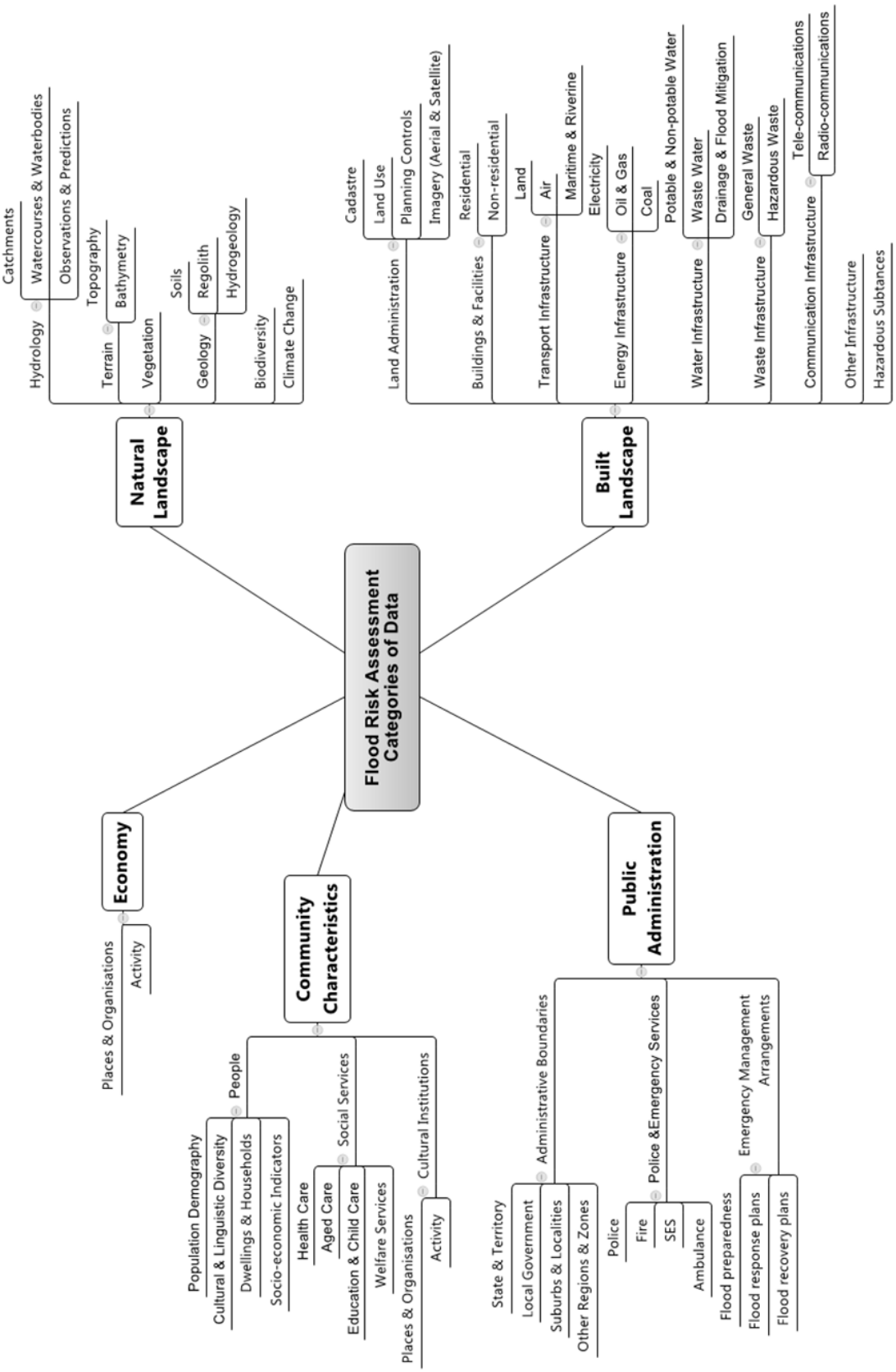

Figure 2 Categories of data for flood risk assessment

Table 2 Data availability, accessibility and suitability

Availability	Accessibility	Suitability
Geography. Some data may not be collected in certain administrative regions or for certain types of catchment or landscape. Collection techniques. Techniques may not exist or may not be effective for collecting some types of data.	Discoverability. A user or potential user must be able to discover the existence of a data-set, and know who the custodian of the data is. Disclosure limitations. The data custodian must be able to release the data to the intending user, and in a way that does not preclude its intended use. Format. The data must be in a format that can be read and understood, whether by a human or software. Cost. End users should expect to meet some or all of the reasonable costs of collecting, storing and disseminating data, but these costs should not be prohibitive.	Currency. The data must be current. This does not mean that the data has to be recent, but it does needs to reflect the state and condition of the phenomenon that it is representing. Accuracy. The data must be accurate. This means there must be a degree of closeness between the actual phenomenon being measured and the data representing it. Precision. The data must be precise. This means that the data measurements must be repeatable and reproducible. Resolution. The data must be able to resolve features at an appropriate scale. Therefore it must be collected at an appropriate scale.

Data-set scale

Just as flood risk assessments can be conducted at multiple scales, data-sets are collected and maintained at varying scales of detail. Organisations which hold data will typically hold data-sets at a scale appropriate for their intended use (Figure 3). This has implications for flood risk assessment, because multiple small scale data-sets are likely to be detailed but not necessarily comparable with each other in the way that the data have been collected, whereas broad scale data-sets will be generally consistent across a large area or period of time, but are unlikely to resolve small scale detail.

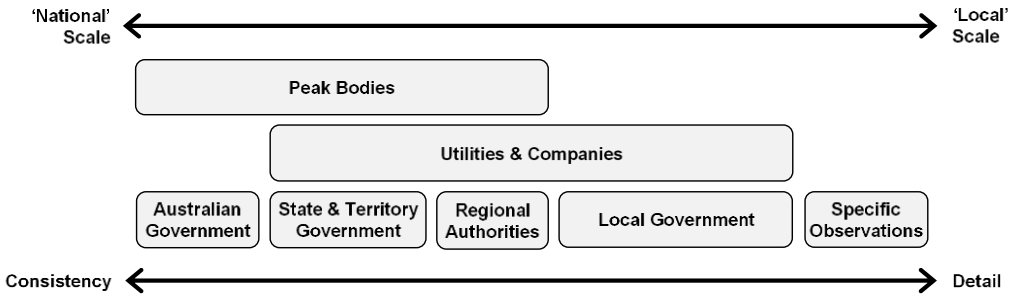

Figure 3 Typical scales of data-sets held by organisations

Assessment of the current situation

The project assembled a schedule of over 400 data-sets from 85 organisations (SAFECOM 2014b). These data-sets were identified from government 'open-data' websites, water information portals, spatial data directories, 'online mapping' websites, and discussions with personnel in key Australian Government agencies including the Australian Bureau of Statistics (ABS), Bureau of Meteorology (BoM) and Geoscience Australia.

The project highlighted the variability in data accessibility and suitability. Differences between jurisdictions did not so often relate to the data-sets available, but more to how openly accessible they were.

The project also highlighted the fragmented nature of relevant data-sets, and the natural tension between national consistency and local relevance. Despite recognition of the need to manage flood risk holistically, which extends to the way that flood risk data is collected, collated and disseminated (see for example the discussion in NFRAG, 2013, s3.3) Australia is a geographically large continent with highly variable climatic extremes. Responsibility for managing flood risk is shared by all levels of government and it is inevitable that data-sets will be fragmented within and across jurisdictions.

More so, each organisation that collects and maintains data has a (necessarily) different interest in doing so. Organisational drivers for collecting and maintaining relevant data-sets rarely relate solely to flood risk or even to emergency management. Other drivers for maintaining data include asset management, natural resources management, service delivery, revenue generation and national security. It is not surprising then that data is spread across multiple formats, multiple systems and multiple custodians.

For these reasons, access to data for flood mapping has evolved to be a shared responsibility and a collaborative effort between commonwealth, state and territory governments, local government, the private sector and affected individuals and communities. The challenge of this shared responsibility is coordinating data accessibility so as to:

- Ensure data can serve flood risk management, as well as other intended purposes, for marginal (if any) increase in the cost to collect it
- Avoid duplication of effort
- Encourage consistency and interoperability
- Address gaps in an efficient manner, pooling resources where applicable, especially for high cost items.

In addition to fragmented responsibilities, anecdotal evidence suggests other challenges to data accessibility include:

- Reducing government investment in the collection and management of social and environmental data-sets. While this can be partially offset by technological advancement and efficiency gains, at some point the quality, quantity, or frequency of observations and updates suffers.
- Legitimate concerns about sharing information that is private or commercially sensitive, particularly information managed by private organisations.

Contrasting these challenges are opportunities offered through technological advancements and shifting paradigms in data and information management:

- Increases in computing power offer the opportunity to collect and process large scale geographic data-sets, run larger and higher resolution models, and undertake more model runs in a given timeframe.
- Surveying techniques such as real time kinematic GPS (RTK-GPS) and airborne laser survey (ALS)—once prohibitively expensive—are now in common use for flood

study data collection. Satellite technology has also developed dramatically in the last few decades enabling access to continental coverage of data.

- There are opportunities to collect and use data in new ways that have not been fully explored in the context of flood risk management:
  - The move by governments to 'open data'[i] policies allows data that was previously 'locked up' to be used for social and economic benefit in ways that may not have been previously considered
  - 'Big data'[ii] offers opportunities to uncover hidden social and environmental information from diverse data streams
  - Social media and the prevalence of 'smart' mobile devices offer new opportunities to capture data during flood events through the possibility of hundreds or even thousands of time-stamped, geo-referenced photographs which could inform future model calibration efforts.

Addressing the issues. What can be done?

As part of the project, a workshop was held in Melbourne on 29 January 2015. The workshop attendees included representatives from NFRAG, Geoscience Australia, local government authorities, emergency response agencies and consulting engineers.

The workshop report was still in preparation at the time of writing. Nevertheless, the workshop validated the earlier conclusion that *accessibility of existing data* was a key issue, as well as highlighting some specific issues relating to climate change guidance, understanding of urban hydrology and exposure data (for building and utilities infrastructure).

Workshop participants were asked to nominate potential projects, activities or actions that could improve ongoing access to data for flood risk modelling. A selection of ideas is presented following:

- There needs to be a national, compelling argument for stakeholders to open up access to flood risk data. Complex legal liability and intellectual property issues need resolution, and it was suggested that the Attorney-General's Department (as the Australian Government's lead agency for emergency management) needs to play a key leadership role.
- A bi-lateral relationship needs to develop with the insurance industry. This would see a network of trust formed which would permit access to historical claims data, suitably aggregated and de-identified.
- The National Exposure Information System (NEXIS) should be expanded with a facility which allows authorised users to submit floor levels and building footprints collected during flood studies, so that this valuable information is not lost.
- There needs to be a long-term commitment to climate reference stream flow stations, especially in urban areas where there is paucity of data, to both inform understanding of climate change and improve understanding of urban hydrology. Obtaining long-term, jurisdictional commitment would likely require regulation and funding inducement.
- There needs to be a consistent national approach to assessing flood damages, with development and national adoption of a smaller number of 'average' flood damage curves as opposed to the current proliferation of methods.
- Strong communities-of-practice need to be promoted, to enhance collaboration, data discoverability and data sharing.

Conclusion

As emergency management in Australia matures from a paradigm of emergency response to one of community resilience flood hazard managers are being challenged to overlay traditional flood inundation maps with more and more social, environmental and economic data-sets. This project has highlighted that it is more than often accessibility, rather than availability of these data-sets, that present barriers to flood risk assessment.

Australia is a geographically diverse nation of eight sovereign states and territories. While there will probably never be utopian consistency in data access or data management, there are steps that can be taken to ensure that data -sets are, and remain, as consistent and as accessible as possible. As the recent national workshop (held for this project) demonstrated, the ideas that drive improvement will not always be contingent on large-scale investment or development of big systems. Many of the suggested improvements could be delivered with relatively modest investment and new levels of cooperation between stakeholders.

Acknowledgements

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[i] Open data is data that can be freely used, modified and shared subject to, at most, measures that preserve provenance and openness.
[ii] Big data analytics is the process of examining high volume/high velocity data of a variety of types to uncover hidden patterns and correlations.

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