The need for private dam safety assurance: a follow-up 'model' policy from Tasmania

McKay and Pisaniello provide a follow-up policy paper on private dam safety

Abstract

Landholders in Australia have often overlooked the common law obligation to review/design dams in line with current standards because of high engineering consulting costs, complacency from believing that as the dam has not failed to now then it will never fail, and because the typical probabilities required for design floods are beyond the average farmer's comprehension. Hence, some form of regulation is needed to reduce the risk to downstream communities to generally acceptable levels. The seriousness of this problem was demonstrated by previous case studies undertaken in the 'still' policy-absent state of South Australia and the 'now' policy-driven state of Victoria.

This paper follows up the previous research by re-enforcing the need for supervision of small dams and their spillways, in addition to the larger, more hazardous dams. Tasmania provides a 'model' on how this can be achieved and its policy has been reviewed comprehensively here. The Tasmanian approach is in line with international best-practice dam safety assurance policy, and is the only state in Australia thus far to acknowledge that even small, low hazard dams need to be supervised, albeit to a modest extent.

Introduction

In Australia, a clear problem exists with private dam safety. Australia has a large number of relatively small, privately owned dams (farm dams especially) and those that have failed number in the thousands. There is an estimated 480,000 farm dams in Australia (Price et al, 2003). In 1992, The Australian National Committee on Large Dams (ANCOLD) estimated that 23 per cent of farm dams in NSW had failed (ANCOLD, 1992).

In Tasmania 445 of the 5,674 registered dams are of significant potential safety risk (Dept of Primary Industries, Water and Environment, Tasmania, 2005, p.21). In Victoria, 800 of the 170,000 farm dams are hazardous (Murley, 1987), and Lewis and Harrison (2002) reported that at least ten significant failures occurred in Victoria in the last decade. The costs of private dam failures associated with public and private infrastructure and the environment are significant, but there is no systematic means of determining this as the failures are seldom publicised and/or recorded (Ingles, 1984). An attempt to estimate these costs was made by Pisaniello (1997) based on only 37 available *recorded* dam failures* in Australia since 1857, finding that:

- of all the failures, only a privately owned dam caused loss of life (14 lives lost)†, and
- the dams 5m to 20m high (this being the typical size range of significant private dams) represent 60 per cent of all the recorded failure. Of these 50 per cent are private dams.

This provides some indication of the sort of costs associated with private dam failures in Australia and the need for policies.

One of the main concerns is that landholders tend to neglect the need for reviewing their dams and instead develop a sense of complacency, believing that as the dams have not failed up to now, then they will never fail (Webster and Wark, 1987; Pisaniello and McKay, 2005). The result is that dams are deprived of necessary maintenance and upgrading and downstream communities are placed at risk. This problem was demonstrated by recent case studies undertaken in the 'still' policy-absent state of South Australia and the 'now' policy-driven state of Victoria (Pisaniello and McKay, 2005). These case studies showed that giving more time, attention and encouragement to farmers addresses the problem to a minimal extent. Adequate assurance can only be provided through appropriate policy which requires the backing of law-makers, and effective and efficient administration of laws.

** 'failure' refers to "a lack of performance as originally intended, which has resulted in a loss of life and/or substantial costs for rectification (ie. more than AU$1,000,000) and/or damage to the environment.*

† this being the Briseis Mining dam in Tasmania in 1929.

For some time, ANCOLD has been aware of this problem and expressed concern (ANCOLD, 1972). Unfortunately, due to high levels of political ambivalence, attempts to enact dam safety Bills have not been successful in all Australian states (Pisaniello, 1997). Dam safety legislation is often considered too 'extreme' largely because of concern that it may place significant cost burdens on both Government and private dam owners to administer and conform with it respectively. However, states which fail to keep adequate registers of private dams, and establish some form of safety assurance policy on the management of potentially hazardous private dams in addition to all small dams that pose a significant cumulative risk of failure, are in effect, unconsciously devaluing the lives of people living downstream of these dams. This is compared with the lives of those living downstream of public dams to which attention has or is being given. This is especially the case in South Australia as clearly demonstrated by Pisaniello and McKay (2005). In contrast, Tasmania recently implemented policy on private dam safety which effectively deals with all the issues raised by Pisaniello and McKay (2005) as barriers to achieving effective private dam safety programs in other states. Hence, the Tasmanian approach is regarded as a 'model' policy for other states to consider, and is discussed in detail here as a follow-up to Pisaniello and McKay (2005).

The significance of the small dam safety problem in Australia

In recent times more farm dams have been built to capture water as changes to the water allocation policies in Australia have been mooted since the early 1990s (McKay, 2001). The costs of private dam failures associated to public and private infrastructure and the environment are significant, based on the limited information available, as are the failure rates. Other studies have also shown that in general dams fail more by overtopping due to inadequate spillway capacity. This failure mode represents 40 per cent of all recorded failures worldwide and embankment dams (which typify private dams) are the most susceptible representing 70 per cent of these (Pisaniello, 1997; ANCOLD, 1992; 1995).

While failures of large dams are generally more spectacular than those of smaller dams and receive much more attention, small dam failures, particularly those of privately-owned farm dams, occur far more frequently (supported by Lewis and Harrison, 2002). Therefore, in many cases, the total annual cost of small dam failures is more serious than the rare failures of large dams. Also, past events have occurred where failures of relatively small dams have caused disastrous consequences. For example, in China the Shimantan and Banquia dams failed in 1975 as a result of the cumulative failure of 60 smaller upstream dams, resulting in the death of 230,000 people (Fu and Quing, 1998). In Italy, the Stava dam near Trento failed in 1985 and while releasing only 180 ML of tailings material, it killed 268 people and caused serious environmental impact (Engels, 2005). In the United States, the Kelly Barnes Lake dam, only eight metres high, failed in 1977 killing a total of 39 people. The Lake Lawn dam in Colorado which was also eight metres high and stored only 830 ML, failed in 1982 drowning three people and causing US$31 million in damage despite warnings and evacuation (Hiser and McDonald, 1989). These past events suggest that without appropriate design, construction and maintenance, poorly managed small dams can cause significant human, property and environmental losses to the community.

This paper looks to address two main concerns with private dams in Australia in line with international experience and practice:

1. Many private dams are unsafe due to improper design, particularly flood capability design, and general lack of review and maintenance. Failure can result which can impact badly on the immediate downstream inundation zone. This concern arises because:

- most landholders hire contractors to build their dams who are typically not properly trained or skilled in the engineering design of dams,
- dam owners are generally complacent with dam surveillance, review and maintenance, and
- the typical probabilities required for design floods are beyond the average farmer's comprehension. Thus, many private dams are not built to an adequate standard. Pisaniello and McKay (2005) provide clear evidence of this.

2. The lack of safety of the small dams individually can lead to cumulative failure during medium to large floods which can produce a flood with high hazard and associated severe downstream consequences. This was demonstrated by the Shimantan and Banquia dam failures and was also found to be of concern in a flood study of the Kangaroo Creek Dam in the Torrens catchment of South Australia (LDC and SMEC, 1995). The modelling procedure adopted in the River Torrens study was reported by Kazarovski (1996). The study found that the peak inflow to Kangaroo Creek Dam would increase fourfold if all the small dams in the catchment failed at the same time (reasonable assumption for an extreme flood event), compared to the flow estimated if the dams remained intact. This meant that only the 1-in-200-years design rainfall in the Torrens catchment would produce a peak discharge similar to the Imminent Failure Flood of the Kangaroo Creek Dam should all farm dams fail. The study thus recognised the need for 'controlling the standard of construction of farm dams and their spillways'.

ANCOLD (2000b, p.10) guidelines on consequence assessment indicate that in cascade situations, the upper dam should take the hazard category for the loss of all downstream dams. This guideline interpreted strictly, and together with the findings of LCD and SMEC (1995) and Kazarovski (1996), would deem that all small dams in a catchment upstream of a large, high hazard public reservoir should also be regarded as High Hazard (due to their potential cumulative failure affect). Therefore each should individually meet the same design standard for a high hazard dam. While this area requires further research in farm dam geometry and stability when overtopped in order to assess the risk properly (Kazarovski, 1996), it has nevertheless become clear that *all* private dams in catchments of large public dams should be registered and at least controlled for spillway adequacy regardless of their size and individual hazard potential. They should be mandated to at least meet ANCOLD's minimum fall-back design criteria for Low Hazard dams (ie 1-in-100-years design flood). Tasmania is the only state so far to acknowledge that even small low hazard dams need to be supervised in such a way.

Dam safety assurance in Tasmania: a 'model' policy

Tasmania has over 30 per cent of Australia's total water storage capacity. Over the last few years there has been a large expansion of storages for irrigation underway to support the sustainable expansion of agricultural production (DPIWE, 2003). Hence, the Tasmanian Government recognised the need to tighten legislative controls in order to ensure the safety of dams in Tasmania. This was achieved by firstly making amendments to the *Water Management Act 1999* (TAS) in late 2002 and then by passing the *Water Management (Safety of Dams) Regulations 2003*, which are now in operation across the State. This policy represents best practice when compared to international standards (see Pisaniello and McKay, 1998 and Bradlow et al, 2002), particularly in terms of the sort of dams that should be prescribed under legislation and the levels of supervision and responsibility imposed upon dam owners.

The Law Reform process

The legislation has been developed in close consultation with dam experts from government agencies, Hydro Tasmania and the mining industry, and with key stakeholder groups such as Tasmanian Farmers and Graziers Association and local government. DPIWE (2003) reported that 'this has enabled the development of statutory dam safety controls that will meet Tasmania's specific needs, facilitate a self-regulatory approach and provide consistency with national guidelines.'

The legislation was introduced in line with the Tasmanian Government's policy to improve safety arrangements for the community and the environment. As a result of the thorough consultation process there was little debate in Parliament about the new regulations on dam owners. It was considered inadequate to solely rely on the non-statutory duty-of-care principles to ensure that dams were maintained in a safe condition. Further, legal advice from Crown Law had indicated that in the absence of statutory dam safety requirements, the Crown may have some liability in the event of a dam failure. The liability would be to the communities downstream and their infrastructure. The owners of the largest private dams are obliged to have an emergency plan and these have been developed successfully in consultation with the local State Emergency Services and local councils.

At the time of introducing the legislation into Parliament, the Minister pointed out that in developing the dam safety legislative framework, the Government's objective had been to achieve the appropriate balance between, on one hand, ensuring public and environmental protection and on the other, imposing restrictive and expensive requirements on dam builders and owners.

The work under the new Act has mainly been with new dams and there has been a surge in these since a 1995 moratorium on taking water from rivers in summer. Over 1000 applications for new dams have occurred in the last five years and some of the new sites are more challenging. There have also been examples of farmers sharing a larger dam.

Description of the dam safety legislation

The legislation provides for specific safety measures to be required for the design, construction and operation of all dams that hold one or more mega litres of water or waste, based on their hazard potential to the community (see s165A of the *Water Management Act 1999* and Part 2 of the *Water Management (Safety of Dams) Regulations 2003)*.

Essentially, under the Act all proposed new dams must obtain a permit (Part 8) and all existing dams have to be registered (Part 8A). The Act is administered by the Department of Primary Industries, Water and Environment (DPIWE), and an Assessment Committee constituted under the Act (see s138). The main role of the Assessment Committee is to assess all new dam permit applications. The Committee must consist of six members appointed by the Minister and nominated by various organisations in order to ensure a collective expertise in areas such as water resources, dams engineering and safety, integrated natural resource management and best practice environmental management (see s139). The ongoing safety of existing dams is supervised by the Minister and the Minister's delegates (primarily officers of the Department).

Section 165G of the Act expressly imposes a duty on all dam owners to, so far as is reasonably practicable, maintain and operate their dams so as not to cause, or be likely to cause, material environmental harm or serious environmental harm or danger to any person or property. Part 8A of the Act gives wide powers to the Minister to supervise and ensure the safety of all registered dams and that owners are not in breach of their duty. As part of this role, the Minister has specific functions under the Act (s165C) which include:

- maintaining a register of all dams,
- ensuring all dams comply with requisite standards of design, construction, maintenance and review as specified under the Regulations, and
- obtaining information and keeping records on matters relating to the safety of dams.

Dam owners can be obligated to provide information on their dams either as a condition of a permit under s157 of the Act or from a direct order from the Minister under various other sections relating mainly to ongoing surveillance and maintenance (eg ss 165F(2), 165H, 165J, 165L, 165M or 165N). The information must be provided by a person of requisite competence as prescribed under the Regulations 2003.

The Regulations 2003 for the most part provide prescribed standards for the competency of persons undertaking design, construction, maintenance and surveillance of dams, based on their hazard categories. The competencies of such persons are classified as either 'any person', 'the owner', persons of either 'Class A', 'Class B' or 'Class C' competence, or an 'Expert Team'. Definitions of these classes of persons in Section 6 of the Regulations include:

- Class A – an engineer with relevant experience in the investigation, design, construction, and day-to-day safety management of dams of a height, type and hazard category similar to the relevant dam. Note: 'engineer' is defined as a person eligible for membership of Engineers Australia, as a chartered professional engineer (Regulations, s3).
- Class B – an engineer with relevant experience in dam technology appropriate to the relevant dam.
- Class C – a professional technical specialist with relevant tertiary qualifications and relevant specialist experience in the investigation, design, construction or day-to-day safety management of dams of a height, type and hazard category similar to the relevant dam.
- An Expert Team – at least one of the persons has Class B competence, and the persons collectively have a knowledge and understanding of the causes and modes of dam failure and also have professional expertise in the following areas in so far as they relate to the relevant dam and activity: engineering surveying, hydrology, hydraulics, engineering geology, soil and rock mechanics, properties of materials, dam design, structural and mechanical design.

Section 7 of the Regulations then provides for varying 'required competency standards' criteria based on the height of the dam, hazard category of the dam, and the type of activity/information to be undertaken/provided. An example of these criteria is provided in Table 1, which is applicable to dams up to 10 meters in height. Other similar criteria are also provided in Section 7 of the Regulations for dams between 10m and 25m high, and for those greater than 25m high. Section 9(1) of the Regulations requires that Hazard categories be assessed in accordance with national guidelines published by ANCOLD (eg ANCOLD 2000a and 2000b). Similarly, all standards of design and safety management must comply with ANCOLD guidelines. These include spillway design standards (ANCOLD 2000a), the frequency and thoroughness of surveillance and review (ANCOLD, 2003) and any requirements for Emergency Action Plans (ANCOLD, 2003).

It is clear from Table 1 and s7 of the Regulations that the legislation in Tasmania encompasses all dams, large and small, low and greater hazard and clearly sets out the level of ongoing safety surveillance. DPIWE (2003) indicates that the owners of significant to high hazard dams are required to arrange safety inspections and reports by an experienced dam engineer after the initial filling of the reservoir and generally every five years during the life of the dam – for typical higher hazard irrigation dams in this category these reports can be expected to cost around $2 000. At the same time, in order to avoid placing significant cost burdens on owners of smaller, less hazardous dams, these do not require full engineering reports. These reports may be prepared by the owner by completing a pro-forma supplied by the Department (DPIWE, 2003). Perhaps, a cost-effective spillway design/review mechanism such as that reported in Pisaniello and McKay (2005), if developed in Tasmania, would well complement this pro-forma process.

Regional Water Management Officers employed by the Department make the initial assessment of a dam's hazard when they do a field inspection of the proposed dam development. This is then checked internally by the Department and if there is any doubt then a conservative approach is taken and/or the proponent is required to have the matter formally reviewed by an engineer. A dam's hazard potential will then determine the Department's mandates as to the frequency of surveillance inspections, reports, safety reviews, and emergency action plans in line mainly with ANCOLD's Guidelines on Dam Safety Management (2003).

There is no fee for registering dams. The policy looks to have all existing dams registered and any new dams are registered when they are granted a permit with the permit application fee covering this cost. Fees for

Table 1. Required competency standards under Tasmanian legislation for all dams up to 10m in height (Source: Water Management (Safety of Dams) Regulations 2003, Section 7)

Activity	ANCOLD Hazard Category*						
	Very Low	Low	Significant	High C	High B	High A	Extreme
1. Supervision of construction	Owner	Class A	Class A	Class A	Expert Team	Expert Team	Expert Team
2(a) Pre-construction investigation, design and report, other than spillway design	Owner	Owner	Class A and Class C	Class A and Class C	Expert Team	Expert Team	Expert Team
2(b) Spillway design	Owner	Class A	Class A and Class C	Class A and Class C	Expert Team	Expert Team	Expert Team
3. Design plans and specifications	Any person	Any person	Class A	Class A	Expert Team	Expert Team	Expert Team
4. Work-as-executed (WAE) report	Any person	(a) Class A, if the dam is more than 7m high; or (b) Owner, if the dam is not more than 7m high.	Class A	Class A	Expert Team	Expert Team	Expert Team
5. Comprehensive or intermediate surveillance inspections and reports	Any person	Owner	Class B	Class B	Expert Team	Expert Team	Expert Team
6. Safety reviews	Any person	Class B	Class B and Class C	Class B and Class C	Expert Team	Expert Team	Expert Team
7. Design and supervision of decommissioning	Any person	(a) Class B, if the dam is more than 7m high; or (b) Owner, if the dam is not more than 7m high	Class B	Class B	Class B	Class B	Class B

*ANCOLD (2000a and 2000b) provides further details on these hazard classifications.

permits are set by the Water Management Regulations 1999 (fees were last updated in October 2005). Current fees are 381 fee units plus –

(a) 54 fee units for each hour spent in processing the application (excluding the first 7 hours);

(b) 214 fee units where the application requires a notice under section 149 of the Act- most dam permits require advertising so this is the advertising cost; and

(c) 421 fee units where the assessment is made by the Assessment Committee- applications for smaller, straightforward dams can be assessed by the Department under delegation from the Assessment Committee. Applications which fall outside this delegation limit incur an extra charge to cover the costs of the Assessment Committee.

The Regulations, s13(1) also require that dam owners pay a fee to the Crown for assessing design, construction, maintenance, surveillance or decommissioning reports in respect of one or more dams as follows:

(a) 25 fee units for the first dam, and

(b) 20 fee units for each 0.5 hours spent in assessing the report – but not exceeding a total of 250 fee units.

Fee units are currently worth $1.17. This provides an innovative and equitable user-pays type method for subsidising the dam safety assurance policy in Tasmania.

Monetary penalties are provided for under the Act and attach to any person failing to comply with any provisions of the Act or orders made under the Act. For example, a maximum fine of 100 penalty units applies to any person failing to provide information to the Minister on the safety of their dam under s165H, and a maximum fine of 200 penalty units and a daily fine not exceeding 20 penalty units (for each day during which the offence continues) attaches to any person failing to comply with a maintenance order under s165L. Body corporates attract fines 2.5 times these levels. Penalty units are currently worth $100.

Finally, the Department provides for substantial owner education and guidance through the publication of website information and articles in Departmental and other publications.

How the policy is currently progressing

DPIWE (2005) reports that implementation of dam safety legislation and regulations following amendment to the Act in 2002 now ensures that best practice safety procedures are followed in the construction, maintenance and surveillance of dams in Tasmania. There are currently 5 674 registered dams in Tasmania, and 445, ie 7.8 per cent of these are sufficiently hazardous to require ongoing statutory safety surveillance and reporting. All of these dams have been placed on a 'prescribed dams' register within the DPIWE dams database. Of these prescribed dams, 60 are High Hazard dams, 268 are Significant Hazard dams, and 117 are Low Hazard dams, greater than 10m high. Around one third of these prescribed dams are owned by organisations such as Hydro Tasmania, mining and other companies, and municipal water authorities who were voluntarily implementing a surveillance and reporting program prior to the 2002 legislative requirements. Hence the remaining two thirds of the prescribed dams are privately owned. Since the introduction of the Regulations 2003, DPIWE (2005) reports that 218 notices have been sent requiring dam owners to undertake a dam safety surveillance inspection. To date, around 70 surveillance reports have been received by DPIWE and either accepted or notices for further information sent.

Conclusion

There is a clear need in areas where hazardous private dams exist to ensure that owners review and maintain their dams in line with current acceptable practice and take appropriate remedial action where necessary. Adequate assurance can only be provided through the implementation of appropriate policy which requires the backing of legislation. The policy must also be extensive enough to ensure that all potentially hazardous dams are supervised. This usually means that adequate funding must be made available for complete administration of the policy, and for an adequate register of all dams to be maintained. This may require some user pays. The experience of Tasmania demonstrates that dam safety programs are workable and not too costly. Elements of best practice can and do exist successfully to control the safety management of private dams and in turn provide increased dam safety assurance to the public and promote the ideals of reducing loss of life as well as environmental and economic losses.

The Tasmanian approach is in line with international best-practice dam safety assurance policy, and is the only state in Australia thus far to acknowledge that even small, low hazard dams need to be supervised, albeit to a modest extent. Most small dams individually pose only a minimal hazard, but when considered cumulatively in a catchment above, say, a large hazardous public dam, they can pose significant risk to premature breach of the public dam, and in turn, extremely serious consequences further downstream. Maintaining an adequate register of all dams, large or small, high or lower hazard, ensures that not only the larger potentially hazardous dams are kept safe, but also the cumulative failure risks posed by small dams are kept in check.

Acknowledgement

The authors wish to acknowledge the Department of Primary Industries, Water and Environment, Tasmania, and especially Mr Max Giblin, Mr Alistair Brooks and Dr Alan Harradine for assistance with information on the Tasmanian Dams Safety policy. Appreciation also goes to Australian Research Council for their interest in this research and for providing the core funding necessary to undertake the foundation research that led to Pisaniello and McKay (2005) and now to this follow-up paper. Thanks also to Mr Arthur Spassis of the Centre for Comparative Water Policies and Laws at the University of South Australia for his research assistance.

References

ANCOLD (1972), 'Report on Safety and Surveillance of Dams', Australian National Committee on Large Dams

ANCOLD (1992), *Status of Dam Safety in Australia*, Bulletin No.91, Australian National Committee on Large Dams, pp. 9–29.

ANCOLD (1995) *Draft Guidelines on Design Floods for Dams*, October 1995.

ANCOLD (2000a). *Guidelines on Selection of Acceptable Flood Capacity for Dams*, Australian National Committee on Large Dams.

ANCOLD (2000b). *Guidelines on Assessment of the Consequences of Dam Failure*, Australian National Committee on Large Dams.

ANCOLD (2003) *Guidelines on Dam Safety Management*, Australian National Committee on Large Dams.

Bradlow, D. D., Palmieri, A. and Salmon, S. M. A. (2002). *Regulatory Frameworks for Dam Safety – A Comparative Study*, The World Bank, Law Justice and Development Series, Washington DC.

Dept of Primary Industries, Water and Environment, Tasmania, (2005), 'Report on the Operation of the Water Management Act 1999', *Report by Water Resources Division*, May 2005.

DPIWE (2003), 'Making Dams Safe for Everyone', *Food and Agriculture: Tas-regions Article*, Dept of Primary Industries, Water and Environment, Tasmania www.dpiwe.tas.gov.au/inter.nsf/WebPages/CPAS-5KA82S?open, accessed 29 November 2005.

Engels, J. (2005) Stava tailings dam failure near Trento Italy, www.tailings.info/stava.htm, accessed 3 June 2005.

Fu, S. and Qing, D. (1998) A profile of dams in China, In *The River Dragon Has Come! The Three Gorges Dam and the Fate of China's Yangtze River and its People*, Thibodeau, J. G. and Williams, P. B. (eds), Probe International and International Rivers Network, Chapter 2.

Hiser, W. & McDonald, L. (1989) Dam Safety, *Water Supply and Resources conf*. proc., Nov. 1988, Sydney, NSW: 163–171.

Ingles, O. G. (1984) A Short Study of Dam Failures in Australia, 1857–1983, *Civil Engineering Systems Journal*, UK, Vol. 1, June 1984, pp. 190–194.

Kazarovski, P. (1996) 'Farm Dams do not Have Impact on Large Floods or do They?' Proc 23rd *Hydrology and Water Resources Symposium*, Hobart, Australia, 21–24 May, pp725–726.

Lange Dames Campbell (SA) Pty. Ltd and Snowy Mountains Engineering Corporation (1995), 'River Torrens Flood Hydrology Study' *A Technical Report for SA Government Engineering & Water Supply Department*, Ref. No. SA485, June, two volumes, pp. 2–3, 40 and 43.

Lewis, B. and Harrison, J. (2002) Risk and Consequences of Farm Dam Failure, 27th *Hydrology and Water Resources Symposium*, IEAust, Melbourne, Aust. May 2002.

McKay J. (2001) The modern Australian history of corporatisation and privatisation of water supplies and irrigation – lessons for the regulators. In *Water history – Lessons for the future*. Hydrological Society of South Australia Inc, Institution of Engineers, Engineering Heritage Branch Stormwater Industry Association, History Trust of SA, p87–97.

Murley, K. (1987), 'Referable Dams in Victoria – Spillway Inadequacy' ANCOLD Bulletin No. 76, April 1987, pp. 24–26

Pisaniello, J.D. (1997). *Analysis and Modelling of Private Dam Safety Assurance Policy and Flood Capability Design/Review Procedures*, PhD Thesis, University of South Australia.

Pisaniello, J.D. and McKay, J.M. (1998). Models of Appropriate Practice in Private Dam Safety Assurance, *Water Policy*, World Water Council Journal, Elsevier Science Ltd, Vol 1, No 5: 525–550.

Pisaniello, J. D. and McKay, J. M. (2005), 'The need for private dam safety assurance policy – demonstrative case studies 10 years later', The Australian Journal of Emergency Management, Vol 20, No 3, pp.15–21.

Price, J., Lewis, B. and Rutherfurd, I. (2003), 'Water Quality in Small Farm Dams', Proc 28th International Hydrology and Water Resources Symposium, IEAust, Wollongong, NSW, 10–14 Nov 2003.

Water Management Act 1999 (Tas)

Water Management (Safety of Dams) Regulations 2003 (Tas)

Webster, K.C. & Wark, R.J. (1987). Australian Dam Safety Legislation, *ANCOLD Bulletin No.78*: 63–78.

Authors

Dr John Pisaniello has multi-disciplinary interests, with honours degrees in Civil Engineering and Law. Following 10 years of PhD and post-doctoral research, John is currently an ARC Research Fellow working on a Discovery project to devise solutions that incorporate complex catchment analysis and modelling, extreme flood hydrology and reservoir hydraulics into simplified "farmer friendly" procedures that promote consistency, uniform standards and policy in private dam flood safety. John's main interests comprise integrating best-practice engineering design and legal compliance into cost-effective technologies, coupled with comparative analysis of international legal systems to assist Australian government policy and legislative reform in the areas of water resources, dams, risk and environmental management, public health and safety assurance.

Professor Jennifer McKay is a Professor of Business law at the University of South Australia who has had over 20 years experience conducting research on national and international urban and irrigation water policy, law and corporate governance issues. She has many publications on flood and bushfire hazards and been commissioned to provide advice by State and Federal Governments. She has over 80 publications in major refereed national and international journals. She is the Director of the Centre for Comparative Water Policies and Laws at the University of South Australia. Refer: http://business.unisa.edu.au/commerce/waterpolicylaw