Funding dam safety regulation: an international comparative analysis and example application in Australia

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Funding dam safety regulation: an international comparative analysis and example application in Australia

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Abstract:

Dam failures that cause significant adverse downstream impacts continue to occur globally. Hence, effective, adequately resourced dam safety regulation is critical for the safety of dams and downstream communities. This paper explores options for regulatory funding and resourcing according to a selected set of relevant key factors along a continuum of dam safety assurance. An international comparative analysis of 15 jurisdictional case studies against the key factors identifies trends representing indicative precedents. A procedure is developed to help identify increasingly relevant precedents for guiding target jurisdictions on potentially suitable options. Illustrative application to a real case in Australia is provided.

Keywords: dam safety assurance, regulation, international case studies, administrative capacity, regulatory funding options, Australia
Introduction

Dams can store water to provide flood protection, power generation, safe and secure drinking water and recreational amenity. Dams also enable successful agricultural production, which is important for the world’s food supply, the development of nations and the global economy. For these reasons, the use of dams as valuable water resources infrastructure has multiplied rapidly over the past century even though construction of new dams has slowed in recent decades (Davies and Simonovic, 2011; FAO, 2011; ICOLD, 2020a). While increasing the number of dams may have benefits for communities and production, it can also place them at risk during floods (Pisaniello et al., 2012). Furthermore, climate change will only increase uncertainty, and extreme weather events, especially floods, are expected to become more severe and frequent (UNIPCC, 2014). Consequently, the risks associated with many dams will increase, especially aging large dams where these excessive flood events are likely to be beyond their initial design parameters (Perera et al., 2021; Pisaniello and Tingey-Holyoak, 2017).

There are around 60,000 large dams in the world (ICOLD, 2020a) and their safe operation has significant economic relevance not only for the benefit they bring but for the potential consequences should they fail. Dam failures are typically low-probability, sudden events, and the consequences of which vary depending on context and definition. For example, past studies have defined dam failure for statistical purposes as a lack of performance as originally intended, which has resulted in a loss of life and/or substantial (i.e. more than US$1,000,000) costs for rectification (Ingles, 1984; Pisaniello et al., 2012). The most recent and comprehensive statistical study by ICOLD (2020b) used a more general definition: catastrophic incident characterised by an uncontrolled release of impounded water; and/or by a total loss of integrity of the dam structure, its foundation or abutments. In reality, and as noted by ICOLD (1995, p.13), dam failures can have varying consequences, where some have been catastrophic, causing up to 2,000 deaths and others of similar magnitude have led to no loss of life. For example Teton Dam, a 123 m high dam located in Idaho (USA), failed in 1976, causing US$1 billion in damage and leaving 11 dead. More recently, the spillway failure of the Oroville Dam, California in 2017 resulted in 200,000 people ordered to evacuate but no fatalities (Wishart et al., 2020).

The failure of large dams receives much attention but are typically rare events. However, smaller and medium sized dam failures occur far more frequently, and their total annual cost can be much greater, including not only economic but also social impacts with disastrous losses (Bocchiola and Rosso, 2014). For example, in China the Shimantan and Banquia dams failed in 1975 due to the cumulative failure of 60 smaller upstream dams resulting in 230,000 deaths (Fish, 2013); in Indonesia the 10m high Situ Gintung
dam failed due to overtopping in 2009 killing around 100 people and causing extensive damage (Pisaniello et al., 2012); in Brazil in 2010, a cumulative series of private dam bursts left 50 people dead and an estimated 150,000 homeless (Pottinger 2010).

Flood damages caused by dam failures are increasing around the world due to increasing asset values and downstream population numbers (Wang et al., 2020; Pisaniello and Tingey-Holyoak, 2017; Vogel, 2015; Bocchiola and Rosso 2014; USDHS 2011). An analysis of recorded failures of (mostly large) dams, expressed as a share of all dams, by continent, reported failure rates in Asia, Europe, North America, South America, Africa and Austral-Asia of 0.49%, 0.79%, 1.17%, 1.17%, 1.29% and 1.46%, respectively (ICOLD, 2020b). These peaked from 1950-1975, with 77 failures, and whilst this number has decreased, it is still rather significant with 40 failures for the period 2000 to 2018 (ICOLD, 2020b). Australia actually experienced an increase in recorded (mostly small) dam failures, from 8 between 1971 to 1990 to 17 from 1991 to 2010 (Pisaniello et al., 2012). Such examples re-enforce the need to ensure continued commitments to sustaining adequately funded regulatory regimes for assuring the safety of dams and downstream communities.

The appropriate policy and regulatory framework for any jurisdiction depends on the specific circumstances. A series of country level reviews of regulatory frameworks for dam safety management and assurance (Pisaniello, 1997; 2011; Bradlow et al., 2002; ICOLD, 2014; Pisaniello et al., 2012; 2015; 2017), including 51 countries by Wishart et al., (2020), show that schemes to control dam safety management vary between and within countries. However, key elements in certain practices can be identified, including: common or civil law, codes or standards of conduct, regulatory administration and funding, registration and classification of dams, surveillance, reporting, emergency preparedness, punitive enforcement and owner education and guidance. The regulatory framework can range from self-regulation to full command-and-control regulation with an independent oversight authority (Wishart et al., 2020; Pisaniello et al., 2012; 2015). When some form of regulation with an independent oversight authority is used, its effectiveness will depend on adequate resourcing, funding and capacity of the regulatory authority (Wishart et al., 2020, p.260). But what are the options for regulatory funding, and how can the most relevant options and indicative precedents be determined for varying jurisdictional circumstances?

These two questions are the focus of this paper and will be answered as follows. Firstly, it will identify the main dam safety regulatory funding options that are available and typically adopted, their pros and cons,
and key factors that can help determine suitability of options for varying jurisdictional circumstances/context. Secondly, it will review 15 dam safety regulatory case study jurisdictions around the world and undertake a comparative analysis of their regulatory funding schemes to identify key factor trends representing indicative precedents. Thirdly, it develops a simple procedure to identify the most relevant indicative precedents that can guide target jurisdictions on potentially suitable options to fund dam safety regulation. Finally, illustrative application of the procedure to a real case in Australia is provided. The paper concludes following a discussion of the potential guidance generated for the Australian case specifically and other countries generally. The paper is limited to regulation of water storage dams, as tailings storage facilities have a different risk profile, and draws on 15 case study jurisdiction reviews from upper middle and high income countries. These typically have more diversified sources of funding from which to draw illustrative precedents, with low income countries typically relying on public funding. The paper does not include case studies from Asia nor include China, India, and Brazil, which account for more than 50% of all large dams in the world (Wishart et al., 2020).

**Dam Safety Regulatory Funding: Background, Need for Guidance, Main Options and Key Factors**

This paper starts from the position that a dam safety regulatory model suitable for a jurisdiction is already in place or has already been chosen, and thus the paper can provide indicative guidance on what funding model may be adequate based on comparable examples, with some examples providing greater relevance depending on the level of coincidence of key factors. The process of designing or reviewing a dam safety regulatory model based on a jurisdiction’s circumstances is already well guided by a global comparative analysis of regulatory frameworks for the safety of dams and downstream communities (Wishart et al, 2020; 2021; reflected also in ICOLD, 2021). This paper relies heavily on the global comparative analysis of regulatory frameworks for the safety of dams and downstream communities by Wishart et al (2020; 2021) and represents a complementary guide on the specific next steps in selecting a suitable funding model.

The following sub-sections provide general background on funding water infrastructure regulation that can develop, impose and enforce obligations; establish the need for guidance in the specific area of dam safety regulatory funding; and identify the main options available for funding dam safety regulatory schemes, their pros and cons, and key factors that can help determine suitability of options for varying jurisdictional circumstances/context.

*Background on water infrastructure regulatory funding*
The economics of regulation relevant to water-related infrastructure has commonly focused on utility services supplied by private firms. Processes for private sector arrangements, such as for urban water supply, are designed to ensure a standard rate of return on capital where ‘rate-of-return regulation’ costs are passed on to consumers through price increases (Perrotton & Massol, 2018). However, price setting in government owned entities assumes the public sector can carry enterprises and departments with below market or even negative rates of return (OECD, 2012). What is adequate for funding regulation of water storage is highly complicated (Quiggin, 1996). In Australia, a further complication is that water corporations are increasingly publicly owned share-wise, yet they must operate more like profit-making private firms, necessarily independent of the regulator that regulates them (NSW Government, 2021; Victoria State Government, 2020). Furthermore, market-based mechanisms related to safe storage of water mostly fail because of the inherent risk to lives and communities (Quiggin, 1996).

When considering the funding elements of regulation for water and water infrastructure, multiple criteria must be balanced, such as regulator’s financial self-sufficiency, equity among users and beneficiaries, and economic efficiency for society (Nauges & Whittington, 2017). Where economic efficiency is a priority for a regulatory body, the basic rule is that economic benefits must exceed costs. For water infrastructure however, there are often market failures and externalities such as common property resource problems and impacts on taxpayers (Nauges & Whittington, 2017). This creates problems for regulators when considering how best to finance regulation. The suite of regulatory and market-based instruments for water-related infrastructure management range from water rights-linked permits to charging for supervision and review (the ‘polluter pays’ principle) (Burchi, 2012). But the position is a highly complicated one because regulation of dams is not just about water infrastructure management, it is at its core also a public safety issue (see Pisaniello & Tingey-Holyoak, 2017 for a review of integration of water management and dam safety policy in Australia). Furthermore, there is the interrelated problem of protecting dam owners against liability (ANCOLD, 2003). As such, financial sustainability of dam safety regulation has many different dimensions (Dollery et al., 2007; Pisaniello & Tingey-Holyoak, 2017).

**Need for guidance on dam safety regulatory funding**

Most OECD countries have well established approaches to dam safety regulation, but adequate resourcing and capacity is a common issue. Wishart et al (2020) found that only 14% of the 51 case study countries have a well-funded dam safety assurance program. As 66% of the case study countries were either high or upper-middle income countries, this means that at least 52% of the case study countries represent developed economies with dam safety assurance programs that are not well funded (Wishart et al, 2020).
This and the limited data available on regulatory funding highlights the need for guidance in this specific area, with the experience from high and upper-middle income countries having a number of important lessons for low and middle income countries as they look to leverage more diversified sources of funding.

Dam safety does not fit neatly into conversations about infrastructure or water policy when it comes to funding regulation. This is especially the case when water storage assets are managed by both private and public owners or publicly owned corporations, which makes governance challenging. This is seen for example in Victoria (Australia) with its 19 state-owned water corporations and where safety mechanisms are strong but resourcing adequate oversight has been a secondary concern (Ram et al., 2021; see also Supplementary Material A). New South Wales (NSW) is another example jurisdiction with complex governance and dam safety oversight resourcing challenges but has recently proposed regulatory funding reform – this will be discussed further and used as an illustrative application case later in this paper.

Economists have argued that regulating safety improvements around what seems like infrequent dam failure events can result in net harm to communities as it draws funding away from improvements to health (Vicus & Aldy, 2003). Research has suggested that regulation that yields a cost per life above US$65 million results in a net increase in fatalities (Vicus, 1994). Consequently, a risk-based approach to reaching a cost per life threshold must be satisfied before a regulation becomes counterproductive (Vicus, 1994; Vicus & Aldy, 2003).

Who pays for implementing policy around dams is challenging as the water they contain is often conceptualised as both a private and public good (Crase, 2010). Policy centred on the safety of dams is even more challenging as it pertains to the risk and uncertainty generated by the water infrastructure itself, which can result in different impacts from other water-related infrastructure such as sewers or pipes (ANCOLD, 2003). Adequate regulatory supervision is directly correlated with the safety of lives, businesses, communities and biodiversity (Pisaniello, 2011). Indeed, when setting standards and classifying dams, a high-hazard dam failure or mis-operation is likely to cause at least one human life lost, meaning one life can be as valuable as several lives. Commonly, such an area of safety would be considered important enough for central governments to bear the costs, but because the benefits of dams quite often go directly to private owners, more creative approaches to financing dam safety regulation have been sought by governments (Wishart et al., 2020). The ‘user’ or ‘impactor-pays’ principle first established in the 1970s requires users of resources to meet the cost of implementing standards or technical regulations (Coffey & Newcombe, 2000). It is considered a form of cost-recovery and as such improves efficiency by forcing dam user consideration of the regulatory framework, reduces pressure on
general revenue sources and makes regulators more accountable for how they implement policy (Australian Government, 2014). It can also create discord in the community.

Therefore, a mix of approaches can work for dam safety. Although there are some examples of such economic and other instruments being applied to dam safety at national levels, there is a lack of in-depth analysis to guide how these principles can work alone or alongside government funding under varying jurisdictional circumstances (see Wishart et al., 2020). Guidance tools that provide a continuum of options and international precedents for varying circumstances based on comparable key determinants are useful to policy makers in the dam safety field due to the unique risks posed. This was identified by the World Bank, which led to developing such a tool for supporting decisions on regulatory frameworks for assuring the safety of dams and downstream communities (Wishart et al., 2020, 2021). This evidences need for a complementary guidance tool specifically on dam safety regulatory funding, as will be developed in this paper.

**Main dam safety regulatory funding options, their pros and cons, and key factors**

The way dam safety regulation is funded and the extent to which it is resourced (i.e. the regulatory funding system) has a direct relationship with the purpose of the dam safety regulation. The purpose is dependent on the context of a jurisdiction. Two key factors that can be used to define the context are (1) the role that the dam safety regulator performs to achieve a certain level of dam safety assurance, and (2) the capacity that the system supports according to the number of dams captured by the regulatory regime and supervised per regulator Full Time Equivalent (FTE) staff (Wishart et al., 2020). Institutional designs of the authority can also largely determine funding strategy, for example, a national dam safety agency will have a different purview than a state or provincial agency. The role ranges from compliance audit through to direct hands-on surveillance, providing an increasing level of dam safety assurance along a continuum (Figure 1).

*Figure 1. Role of dam safety authority continuum providing increasing dam safety assurance (adapted from Wishart et al., 2020, p.265)*
There are three main options for funding a dam safety regulatory scheme (Wishart et al., 2020). These are linked to the role of the regulator and the capacity that the system must support and include the following.

**Option 1: Fully funded by government from general tax revenue**

This is simple to administer and does not risk overburdening dam owning sectors that have small revenue streams, such as the irrigation and farming sectors. This method also avoids industry outrage, resistance and political pressure from such sectors. However, there is arguably some inequity as everyone in the community pays for the scheme whilst not everyone gets the benefits of the scheme (as not everyone lives below a dam and needs to be protected) (Morales-Torres et al., 2019). The counter-argument of this is that everyone benefits from the supply of either water (from water supply dams), power (from hydro dams), or food (from irrigation/farm dams) so it is fair and equitable for everyone to be paying for the scheme from general tax revenue (Boryczko and Rak, 2020). However, it is also generally accepted that this approach does not promote regulatory efficiencies (Biggar, 2012).
This works by government holding resources and having budgets submitted from various departments for allocation to administering regulation across human and other necessary resources. State and local governments at the sub-central level, in principle, have access to these resources if they are granted. However, discretion over how the funds are used varies considerably, and often, little autonomy exists, especially when it comes to issues such as dam safety, which can seem remote to some budget holders (Blöchliger & King, 2006). Typically grants are handed out from central revenue in line with government function. Of the 51 countries studied by Wishart et al. (2020), 14% fund dam safety regulation entirely from central government revenue, including Queensland (Australia), Japan, and South Africa.

**Option 2: User-pays (also referred to as impactor-pays)**

The argument for the approach of full-cost recovery is that dam owners use the dam infrastructure that creates the risk requiring regulation, and so they should pay for it. Dam owners would pass on the cost as part of their normal course of business to the community or its consumers, who are the ultimate beneficiaries of the goods and services that come from dam-using businesses. But it is acknowledged that inequity can exist with this approach when downstream communities whose interests are covered by the regulation are not the paying customers of the goods or services that come from the dam (e.g. a hydropower dam that exports power to a neighbouring country).

This method allows for full cost recovery through either a periodic fee or levy (usually annual), such as fees related to dam registration, permits, licences, inspections, or audits. The costs to be recovered include staff salaries to work on review, inspection, and administration as well as on costs to maintain training in dam safety standards (Assaad & El-adaway, 2020). Alternatively, more specific fee-for-service type charges can be adopted for regulatory activities such as issuing permits or inspection.

This approach, when applied broadly across ownership types (private/public dam owners) or sectors (water supply/hydro/irrigation) can also create inequities between dam owners that can afford to pay the fee(s) due to their higher revenue streams or ability to pass on costs to consumers (e.g. publicly or privately owned water corporations/water suppliers, hydropower operators) compared to dam owners that have much lower revenue streams (e.g. private irrigators/farmers). Furthermore, in the case of rural bulk water services, it has been suggested that the underlying infrastructure of the dam provides services to the broader community such as flood mitigation or environmental monitoring benefits (Biggar, 2012). Of the 51 countries studied by Wishart et al. (2020), only 4% fund dam safety regulation fully from a user-pays mechanism, such as Norway. However, there are examples of separate regulatory jurisdictions within
certain countries that rely significantly on user pay mechanisms, such as Tasmania (Australia), Ontario (Canada) and from the USA the states of California and Washington, and the Federal Energy Regulatory Commission (FERC).

**Option 3: Mixed (combination of government funding and user-pays)**

A mixed model is a common form of funding for dam safety regulation. This means that the benefits of both types of funding (government-funded and user-pays) can be harnessed, providing equitable funding for assurance of infrastructure from which the user benefits, supported and supplemented by non-specified government revenue. In fact, there is an economic justification for allocating some of the costs incurred by a dam owner to the government where there are changes in the regulatory requirements over time (such as changes in dam safety), which would, in other industries, be phased in over time (Biggar, 2012). In addition, charging a fee for service can be difficult to legislate, and so a partial levy plus government funding can work as an optimal mixed model. Of the 51 countries studied by Wishart et al. (2020), the majority (28%) fund dam safety regulation through a mixture of government general revenue funding and payments generated from users. Examples include Victoria (Australia), Alberta (Canada), United Kingdom (UK), Sweden and Brazil.

**International Comparative Analysis of Dam Safety Regulatory Funding Schemes**

A detailed review and comparative analysis of the funding options for dam safety regulatory funding was carried out based on a subset of the 51 country case studies prepared by Wishart et al., (2020). These countries are estimated to account for more than 95% of the world’s large dams and the case studies detailed their regulatory frameworks, including the institutional and financial arrangements which are relevant to this paper (see Wishart et al., 2020: Appendix B for the extent of information sought for each case study). The analysis here involves reviewing the regulatory funding systems adopted across a set of selected jurisdictions with varying circumstances and comparing the results with regard to the main options/sub-options and two key circumstantial factors identified in the previous section. The 15 case studies were selected based on reasonable data being available on the regulator financing system adopted as well as the context in which the system is used. This context is represented by two main simplified proxy factors in this study: (1) the role that the dam safety regulator performs under the dam safety regulatory regime according to Figure 1, and (2) the capacity that the system supports according to the
number of regulated/supervised dams per regulator FTE staff. The analysis enables identification of trends which can be regarded as indicative precedents on the options for funding dam safety regulation.

The international review

Fifteen jurisdictions were selected for review based on the criteria above. These include Victoria (Australia), Tasmania (Australia), Queensland (Australia), New Zealand, UK, Portugal, Norway, Alberta (Canada), Ontario (Canada), California (USA), Washington (USA), FERC (USA), South Africa, Sweden and Argentina. ‘Jurisdiction’ here refers to the regulatory jurisdiction of a dam safety authority which can transcend borders, such as is the case with FERC in the United States and some prevailing aspects of the UK’s system, as follows. In the United States, for dams owned by institutions of the federation such as US Army Corps of Engineers and the Bureau of Reclamation, dam safety is the responsibility of federal government and it is self-regulated. For all remaining dams, dam safety regulation is the responsibility of individual state governments, and the regulations and institutional arrangements vary from state to state. The exception is non-Federal hydropower dams which are regulated for dam safety by not only the applicable State dam safety agency, but also separately by the federal institution, FERC. In practice FERC coordinates with and assists State agencies (Wishart et al, 2020), and this unique situation in the US warrants including FERC as a case study jurisdiction. With regard to the UK, whilst it is decentralising regulation amongst England, Wales, Scotland and Northern Ireland (see UK review in Supplementary Material A for further details), it is referred to as the UK jurisdiction here as the UK’s Environment Agency has traditionally played this role and still provides oversight. Also the system of Panel Engineers provided for under the Reservoirs Act still prevails amongst the current regulations in all four countries, representing a unique form of user pays oversight throughout the entire UK jurisdiction.

The remaining jurisdictions from Wishart et al., (2020) had insufficient information to enable comparative analysis of either the funding system adopted and/or the circumstantial proxy factors. Wishart et al. (2020) notes that out of the 51 case study countries studied, information on the financing mechanisms for the regulatory regime are often difficult to determine and no data were available in nearly one-third (31%) of cases. For another quarter (25%), there was no formal regulatory oversight mechanism in place and so no dedicated funding mechanism required. In effect, the 15 jurisdictions reviewed provide mostly representation of high and high-middle income countries (14/15), with only one low-middle income country (South Africa).
The detailed reviews of the 15 case study jurisdictions are presented in Supplementary Material A. The reviews are based mostly on the findings of the Wishart et al (2020) and updated where possible. Each review pays particular attention to how dam safety regulation is funded (including what main option/sub-option is adopted) and the two key circumstantial factors identified above. Any other unique options, circumstances or lessons that emerge from the review are also noted. The reviews are used in the following comparative analysis to help identify useful trends and indicative precedents on dam safety regulatory funding across the varying jurisdictional circumstances of this dataset.

The comparative analysis, trends and indicative precedents

The comparative analysis of the funding system for the regulation of dam safety is based primarily on the main options and sub-options identified previously, and provides an indication of the most common forms adopted amongst the selected case study jurisdictions (Table 1). Then, further comparative analysis provides the context in which these systems are used, namely the role of the dam safety regulator (Table 2) and the capacity that the system supports represented by the number of regulated/supervised dams per FTE staff (Table 3).

There is strong precedent and support for adopting user-pays systems to support, or progress towards, full cost recovery basis (Table 1: 8/15), as well as systems that supplement these with government general revenue via a mixed funding system (5/15). Systems that are fully funded by government are the least common (2/15). It is important to note, however, that the analysis is limited to these 15, mostly upper-middle and high income jurisdictions where information is readily available on the key determinants of effective regulatory funding. South Africa is the only lower-middle income country included in the analysis.

Further analysis of user payments demonstrate that the most common forms relate to either a registration, licence and/or permit fee for either the dam itself or the water it stores. This sort of direct fee arrangement is observed among almost two-thirds (8/13) of the case studies for which there is user-pays system funding only, or where there is a mixed system. Examples include Victoria, Tasmania, UK, Alberta (Canada) and Norway. This means that the revenues derived from the use of the structure and the storage of water are directly provided back to the system to assure the safety of the structure for the benefit of users and the region as a whole.

A more direct user-pays mechanism is adopted in over one-third of such cases (5/13) where there is a direct supervision, inspection, review and/or auditing fee charged, based on either a fixed fee for a service, the class of the dam, or on a time-spent basis. Examples include Sweden, Tasmania, Washington,
California and UK (as per Scotland, which charges a fixed fee when a dam owner requests a review of the regulator’s risk designation). This more closely ties the service of dam safety regulation to the benefits received by users and ties the safety performance of the infrastructure to the financing of the dam safety regulatory scheme.

There is also precedent for adopting a user-pays system via the charging of some sort of annual fee, levy, and or tax (Table 1: 5/13). Examples include UK, Portugal, Norway, Sweden and Argentina. This charge is usually related to the class of the dam representing the time, effort, resources, and or staffing needed by the dam safety regulator to periodically audit dam safety review information. This funding could be further supported by more specific and uniform registration, licence, or permit fees, but the UK (Wales and Scotland) currently provides the only precedent for such a combined approach. In fact, the UK provides a noteworthy example of additional user-pays through a system of independent Panel Engineers provided for under the 1975 Reservoirs Act, which has been integrated into the current regulations in the four countries. Under this system, the dam owner is required to consult an independent Panel Engineer selected from the Panel register (a government approved register maintained by the Environment Agency for England and Wales and the respective reservoir safety agencies for Scotland and Northern Ireland). The Panel Engineer periodically inspects and assesses the safety of the dam and reports to the main oversight authority, and the associated consulting fees for this regulatory inspecting are borne by the dam owner.

There is some international precedent on differentiating user-pay fees with different financing mechanisms aligned to the revenue streams specific to the Government policy related to the sector. This can be according to sector, such as dam ownership (i.e. private, public, see Victoria) and dam industry (i.e. water supply/water corporations, hydropower, irrigation/farming, see Argentina, Victoria, FERC). Different financing mechanisms are employed in different sectors in 18% of the 51 country case studied by Wishart et al (2020), including China, Indonesia, Vietnam and Chile, with funding differentiated based on ownership in 8% of cases, such as in Victoria. This differentiation allows the regulatory regime to take advantage of differences between revenue generating potential. It also allows an opportunity to cross-subsidize dam safety regulation across sectors. From the above review, Argentina represents a unique alternative mixed system where, for the hydropower sector, the regulator’s expenses are financed with contributions from the National Treasury as well as a tax on the extent of hydroelectric generation. In this way, hydropower dam owners pay to support the activities of the regulator in proportion to their revenue/profit streams.
Importantly, institutional design of the authority can determine the funding strategy. For example, a national dam safety agency will have a different purview than a state or provincial agency, and both types are represented in the data in Tables 1 - 3. Also, other institutions may exist that provide complementary or supporting roles to the main dam safety regulator under consideration. For example, in the US, FERC assists the role of state regulators in the regulation of non-Federal hydropower facilities, whilst Federal agencies such as the US Army Corps of Engineers and the Bureau of Reclamation have allocated government budgets under their respective agencies for self-regulating Federal dams, with specific provisions such as Chapter 19 of USACE (2014) which is headed Program Administration and Funding Processes. The main role of regulating private and state-owned dams falls upon State dam safety authorities, and in the US, there also exists the possibility of funding support from the Federal government to the state agencies. This support works through provision of assistance to the states through the Federal Emergency Management Agency (FEMA) and the National Dam Safety Program (NDSP). The NDSP initially authorized under the Water Resources and Development Act of 1996, and re-authorized (through to fiscal year 2011) under the Dam Safety Act of 2006 and again until present under the Water Resource Reform and Development Act (see FEMA, 2016; 2021) includes the provision of grants to the states for the improvement of state dam safety programs, but these grants are only distributed among the states which have successfully established dam safety programs approved under the terms of the act, i.e., in line with the Model State Dam Safety Program (FEMA, 2007). States with approved dam safety programs then continue to receive grant money from FEMA to help sustain the program.

Table 1. Regulator financing system used in the 15 case study jurisdictions
The analysis shows that the most common form of regulator role is quality assurance (Table 2: 9/15). This includes more hands-on regulation, such as through scheduled and detailed audits, or regulators may take responsibility for consequence classification. The pure compliance-audit role where the regulator performs the occasional random audit but typically relies on the owner’s engineer’s reports does not require considerable regulator capacity and is adopted in only 20% of cases. On the other end of the spectrum, the direct surveillance role where the regulator takes on a lot of responsibility in dam safety reviews and decision making and so requires considerable regulator capacity and resourcing, is similarly adopted in 20% of cases.

Finally, with regard to the capacity that the dam safety regulatory funding system supports, the analysis shows there is extensive data available on the number of dams regulated/supervised (Table 3: 14/15) and considerable data on the number of FTE staff (8/15). This data helps to contextualise any comparisons between the case study jurisdictions, and can help identify the strength of indicative precedents for other jurisdictions. The following section utilises the comparative information from the analysis to develop a
simple systematic procedure that can help guide jurisdictions on the pursuit of suitable dam safety regulatory funding.

Table 2. Role of regulator in the 15 case study jurisdictions

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<th>Jurisdiction</th>
<th>Compliance audit regulator role, eg just occasional random audits, very hands-off</th>
<th>Quality assurance, more hands-on regulator role, eg more scheduled and detailed audits, regulator may take responsibility for consequence classification</th>
<th>Direct surveillance/very hands-on regulator role, eg regulator takes on a lot of responsibility in dam safety reviews and decision making</th>
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<td>California</td>
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<tr>
<td>Washington</td>
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<td>FERC</td>
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<td>South Africa</td>
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<td>Sweden</td>
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<tr>
<td>Argentina</td>
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</tbody>
</table>

*Whilst the regulator is generally not considered to be hands-on in Victoria, there is some quality assurance role simply because the regulator does collect, monitor and reports on information it collects as part of its quality assurance for public water corporation dams (Ram et al., 2021). This is a form of embedded regulatory effort towards dam safety in Victoria.

Table 3. Capacity supported by the regulatory financing system for the 15 case study jurisdictions represented by number of regulated dams and FTE staff where such information is readily available

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Internal capacity of regulatory system</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIC</td>
<td>8300+ dams / 1.5 FTE</td>
</tr>
<tr>
<td>Tas</td>
<td>10,000 dams / 3 FTE</td>
</tr>
<tr>
<td>QLD</td>
<td>108 dams / 18 FTE*</td>
</tr>
<tr>
<td>NZ</td>
<td>Regulatory framework not yet developed/implemented</td>
</tr>
<tr>
<td>UK</td>
<td>2097 dams (England); 371 dams (Wales)</td>
</tr>
<tr>
<td>Portugal</td>
<td>716 dams</td>
</tr>
<tr>
<td>Norway</td>
<td>6000+ dams</td>
</tr>
<tr>
<td>Alberta</td>
<td>1500+ dams / 10FTE</td>
</tr>
<tr>
<td>Ontario</td>
<td>3000+ dams</td>
</tr>
<tr>
<td>California</td>
<td>1254 dams / 60FTE</td>
</tr>
<tr>
<td>Washington</td>
<td>111 dams / 9FTE</td>
</tr>
<tr>
<td>FERC</td>
<td>2525 dams / 132FTE</td>
</tr>
</tbody>
</table>
A simple procedure that can guide jurisdictions on suitable dam safety regulatory funding options and illustrating its application

The various trends and indicative precedents identified through the analysis may be more or less relevant to any particular jurisdiction depending on coincidence of circumstances. In order to help identify increasingly relevant indicative precedents from the case studies dataset that can guide any particular target jurisdiction on options for funding its dam safety regulation, a simple systematic procedure has been developed (Figure 2). It is important to note that ‘relevance’ determined from this procedure will be more applicable to upper-middle and high income economies since these currently dominate the database. However, lower-middle and low income economies may also generate useful indicative guidance if the simplified circumstantial proxy factors are considered satisfactory by decision makers of any particular country and provide an important transition pathway to more diversified sources of funding that can alleviate pressure on public resources that are typically under a number of competing demands.

Illustrative application of the developed procedure to a real case in Australia is then also provided in this section.

Simple procedure for guiding target jurisdictions on increasingly relevant indicative precedents

The simple systematic procedure was developed on establishing increasing coincidence between a target jurisdiction and the case study jurisdictions with regard to the following 3 key characteristics:

1. Whether the regulatory funding option is based on either user-pays only, government funding only, or a mix of government funding and user-pays (per Table 1);
2. Whether there is a comparable regulatory framework where at least the role/activities of the regulator are generally similar in terms of how hands-on the regulator is (per Figure 1 and Table 2); and
3. Having some comparative data available on regulator resourcing/capacity (i.e. FTE staff) and the number of regulated dams (per Table 3) so that this can be proportioned relative to the target jurisdiction’s data.
Figure 2 demonstrates the process across three main areas of economic instrument choice, regulatory framework elements and capacity indicators, where for the target jurisdiction the respective data under consideration is either actual or proposed. Applying the process generates a ‘comparative jurisdiction results matrix’ that orders the indicative precedents from the case study jurisdictions in descending order of precedent strength. This matrix provides useful comparative guidance on suitable regulatory funding for a target jurisdiction and could be used as a decision support tool by policy makers.
Figure 2. The simple procedure: elements and indicators to develop a matrix of increasingly relevant comparative guidance on suitable regulatory funding
**Illustrative application to determining an appropriate funding system for dam safety in New South Wales, Australia**

NSW is currently undergoing dam safety regulatory reform including consideration of a new ‘dam safety levy’ approach to regulatory funding (see Supplementary Material B for a review). Hence, this jurisdiction provides an ideal example to illustrate application of the simple systematic procedure.

Firstly, it is necessary to derive precedents and lessons in so far as they are relevant to NSW. From the procedure and 3 key determinants illustrated in Figure 2, to be reasonably comparable to NSW it is necessary to identify schemes that:

1. are based on either user-pays only or a mix of government funding and user-pays as this is what NSW is proposing with the dam safety levy approach (see Supplementary Material B),
2. have a comparable regulatory framework where at least the role/activities of the regulator are generally similar in terms of how hands-on the regulator is (NSW has a quality assurance type regulator but has become less hands-on and much more compliance audit under the recent regulatory reforms, see Supplementary Materials B), and
3. have data available on regulator resourcing/capacity (i.e. FTE staff) and the number of regulated dams so that this can be proportioned relative to the proposed NSW data (i.e. 22.5 FTE + 5 Boards members / 400 regulated dams).

The level and strength of precedent/guidance represented by the comparable schemes is then dependent on the level of coincidence amongst these 3 key determinants as detailed in the above procedure (Figure 2, Precedent Strength A - D). This level of coincidence with NSW can be assessed and presented in a comparative jurisdictions results matrix as illustrated in the Supplementary Materials C, and the following indicative guidance is then generated according to precedent strength.

**A. Strongest indicative precedent**

Of the jurisdictions that adopt some sort of general dam safety fee, levy or tax similar to the NSW proposed regulatory funding model, the strongest indicative precedents and guidance emerge as follows (see Supplementary Materials A for more details on each jurisdiction):

- Portugal: Base the dam safety fee/levy on both dam consequence class and dam size as well as the stage of development/construction/operation as this better represents the complexity of the
dam safety information and the time/resources needed by the regulator to review the information.

- Norway: Base the dam safety fee/levy on both dam consequence class and dam size as this better represents the complexity of the dam and the time/resources needed by the regulator to review safety information.

- Sweden: Provides some support to the proposed NSW levy approach of differentiating the levy according to consequence class only. But this is only to establish a baseline minimum fee. The further potential differentiation associated with the complexity and time/resources needed by the regulator to review safety information for different size dams is then accounted for more accurately on an additional time basis fee.

- UK: Provides some support (from Wales and Scotland) to the proposed NSW levy approach of differentiating the levy/subsistence according to consequence/risk class only. But in order to help recover a majority of their direct regulatory and administrative costs Scotland also charges a considerable once-off registration fee and a risk designation review fee.

- Argentina: Acknowledging that different sectors have larger revenue streams than others, and some dam owners within sectors may be more well off/profitable than others, a user-pays dam safety fee can also be based on a tax on the dam owner’s level of productive output/revenue.

B. Considerable indicative precedent

Jurisdictions that provide considerable indicative precedents and guidance on other options for user-pays regulator funding include:

- Tasmania (Australia): Having a user-pays system that is completely time-based (on top of a uniform base fee for initial permits) provides the most accurate representation/differentiation of the complexity and time/resources needed by the regulator to review safety information for different dams irrespective of dam size and consequence class. The levels of the time-based fees in Tasmania however may require attention as the number of FTE staff that it is currently supporting is clearly insufficient to provide adequate oversight of such a large regulated dams portfolio.

- Alberta (Canada): Provides further general support to the proposed NSW user-pays regulator funding approach. But the regulator in Alberta has been found to experience a number of
challenges in implementing and administering the regulation of over 1500 dams with just 10 FTE staff who are funded by a mix of government general revenue funding and user-pays licence fees. This indicates that more extensive user-pays fees are necessary and/or supported by more extensive government funding in order to increase regulator resourcing and staffing. This highlights the importance of getting the levels of user-pays correct to ensure the regulator has sufficient capacity to perform its mandated role and to enable full cost recovery of this.

C. Moderate indicative precedent

The jurisdictions that provide moderate indicative precedents and guidance for NSW on user-pays funding include:

- Victoria (Australia): Provides example of a jurisdiction that differentiates regulator funding according to sector (private vs public). Also shows how under-resourced/-staffed a regulatory jurisdiction can be when based only on funding from government general revenue (public dams) and limited user-pays licence fees (private dams). There are no user-pay fees for public dams as these dam owners are considered to be well off enough to invest the necessary funding and resources within their dam safety management systems so as to warrant minimal hands-on attention by the regulator. This approach to regulatory funding has worked reasonably well to date for providing an oversight framework that is generally consistent with good practice in Australia and internationally. However, it has not enabled the dam safety regulator to perform some basic fundamental oversight roles including conducting audits (not even randomly) and maintaining a publicly available consolidated register of regulated dams (Ram et al., 2021).

- New Zealand: Provides further general support to the proposed NSW user-pays regulator funding approach.

- Ontario (Canada): Further supports the proposed NSW user-pays regulator funding approach which this jurisdiction considers to be necessary to support oversight of around 3000 regulated dams on a less hands-on basis.

- California (USA): Further supports the user-pays approach to ensure full cost recovery to support the regulator to perform its role no matter how extensive/hands-on it is. The number of FTE staff funded in California is proportionally around that proposed for NSW (ie around 20 FTE per 400 dams), but California is much more hands-on compared to NSW, so further efficiencies may be worth considering for the NSW regulator. California also aligns with the belief that the size of the
dam best represents the complexity of dam safety review and the time/resources needed by the regulator to undertake such reviews.

- Washington (USA): Provides further support to the user-pays approach to support the regulator to perform its role no matter how extensive/hands-on it is. But it aligns with the belief that having a user-pays system that is largely time based/fee-for-service provides the most accurate representation/differentiation of the complexity and time/resources needed by the regulator to undertake inspection/safety reviews for different dams irrespective of dam size and consequence class. The number of FTE staff funded in Washington is proportionally double that proposed for NSW (ie around 20 FTE per 400 dams in NSW compared to around 20 per 200 dams in Washington), and as Washington is much more hands-on compared to NSW, this supports the proposed FTEs for NSW and implies that no further efficiencies may be worth considering for the NSW regulator.

- FERC (USA): Further supports the user-pays approach via charging of annual fees to ensure full cost recovery for supporting the regulator to perform its role no matter how extensive/hands-on it is, especially in a sector such as hydropower generation where revenue streams are high. The FERC system also aligns with the belief that the extent of the fee should be proportional to the level of benefit gained from the dam by the dam owner, possibly represented by the amount of power generated or revenue/profit levels. The number of FTE staff funded in FERC is proportionally around that proposed for NSW (ie around 20 FTE per 400 dams), but FERC is much more hands-on compared to NSW, so this may imply that further efficiencies may be worth considering for the NSW regulator.

D. Weakest indicative precedent

Finally, jurisdictions that regard fully funded government systems as suitable (unlike NSW’s proposed system) may still offer some merit for comparison and potential lessons. These include:

- Queensland (Australia): Offers minimal precedent/guidance to NSW, as indicated by CIE (2020, p.16) whilst the QLD benchmark provides an order of magnitude, there are large differences between the regulatory framework in Queensland and in NSW which reduce the benchmark’s relevance. Comparability with NSW is further reduced as Queensland is fully government funded (ie no user-pays). But the number of dams the QLD regulator supervises per FTE staff
(around 6 in QLD compared to around 18 proposed in NSW) provides some indication of the sort of regulatory efficiencies that can be achieved via a user-pays full cost recovery system compared to a fully government funded system.

- South Africa: Provides an example of a significant portfolio of regulated dams (>5,000 dams) that relies only on existing government funding. The regulatory provisions exist for the regulator to shift to a user-pays system, similar to NSW. Competing demands over limited government resources impose a number of challenges for the regulator with implications for the staffing and resources needed to fulfil regulatory mandates.

Discussion

This section consolidates the results and discusses the implications of the international comparative analysis and developed guidance procedure/tool both generally and as applied to NSW specifically.

Common models and theorising on funding water management regulation range from fee-linked water rights to user-pays approaches. For dam safety regulation and assurance, there is considerable international precedent for user-pays systems on a full cost recovery basis via the charging of an annual fee/levy related to the class of the dam reflecting resources needed to administer. This fee/levy can be further supported by more uniform registration, licence or permit fees and supplementing regulator funding with government general revenue funding where necessary. Hence the regulator funding system proposed for NSW is generally appropriate in relation to international practice and indicative precedent. It will also help cater for increased purview/capture of the regulation as projected by CIE (2020, p.32). These findings are relevant to higher income economies that currently dominate the comparative database. Hence, the following discussion of the more specific findings and considerations, and their illustrative application to the NSW case, may not be as relevant to developing economies with less developed fiscal systems.

The core benefit of user-pays is that it promotes regulatory efficiencies in that the dam owners that use the dam infrastructure creating the risk pay for it, rather than the entire community as is the case under government funded schemes. Dam owners then pass on the cost as part of their normal course of business to the ultimate beneficiaries of the goods and services that come from dam-using businesses. At the same
time it must be acknowledged that inequity arises when downstream communities at risk of the dam are
at times not the paying customers of the goods or services that come from the dam.

The most common form of user payments observed internationally relate to either a registration, licence
and/or permit fee for either the dam itself or the water stored (examples include Victorian private dams,
Tasmania, UK, Alberta, and Norway). This direct fee arrangement means that the revenues derived from
the use of the structure and water are directly provided back to the system to assure the safety of the
structure for the benefit of users and the region. This is an option that could be considered for NSW to
provide some base regulatory funding to supplement user-pays funding more contingent on dam class or
time (e.g. Tasmania, UK, California and Washington). But this is an option only if such payments would
satisfy the explicit provision of a levy under the Dams Safety Act 2015 (discussed further below).

A more direct user-pays mechanism is also adopted in many cases where a fee is charged in relation to
the supervision, inspection, review and/or auditing role of the regulator, based on either a fixed fee for
the service, the class of the dam or on a time spent basis (examples include UK, Sweden, Tasmania,
California and Washington). This not only closely ties the service of dam safety regulation to the benefits
received by users, but can more closely tie safety performance to regulatory financing (ie well performing
dam owners require less attention from the regulator and so pay less fees).

Currently the proposed NSW levy system is based on dam consequence class only for which there is some
precedent (see Sweden, UK and California). The proposed system does not take advantage of the finer
classification available amongst High consequence dams and hence potential for more accurate
differentiation of the levy. Most of the strongest precedents identified above indicate that user-pays
systems should be differentiated based on both dam size and consequence class as this better represents
the complexity of information and time/resources needed to review (per Portugal and Norway, also
California). If only dam consequence is to be used, a standard base-line fee can be set but should be
supplemented by a time-based fee (per Sweden, see also Tasmania, UK/Scotland and Washington).

The most accurate representation of complexity of dam safety information and time/resources needed
by the regulator to review the information would be provided by a fully time-based system. Tasmania
provides an excellent example as does Washington and the UK’s system of Panel Engineers for the
independent inspection of dams. This system minimises inequities that may arise from both sides of the
argument against class only-based systems. One side of the argument being that smaller dams should not
pay the same fee as large complex dams and so the contents of safety reports will require less review
effort. The other side of the argument being that owners of higher consequence class dams are often better resourced to have proper dam safety systems in place and reports require less effort by the regulator for review.

Given these significant indicative precedents and advantages of a time-based fee in relation to the supervision/auditing role of the regulator, either solely time based (e.g. Washington) or to supplement a fixed base fee (e.g. Tasmania, Scotland), it may be an option for NSW to consider. But again, this is an option only if such time-based payments would satisfy the current explicit provision of a levy under the Dams Safety Act 2015 (NSW Government, 2019). As ‘levy’ is not defined under the Act, CIE (2020, p.3) indicates that based on legal advice provided to Dams Safety NSW, current legislative arrangements do not enable a fee-for-service. Hence, introducing this option may first require the Dams Safety Act to be amended by the legislature.

Another key consideration for any user-pays regulator funding system is the affordability of the requisite fee and the financial burden it may place on more disadvantaged sectors (e.g. irrigation/farming). There is some international indicative precedent on differentiating user-pay fees according to dam ownership (i.e. private, public, see Victoria) and dam industry sector (i.e. water supply/water corporations, hydro, mining, irrigation/farming, see Argentina, Victoria, FERC). Acknowledging that different sectors have different revenue streams, a user-pays dam safety fee can also be based on a proportional tax-like fee on the dam owner’s level of productive output/revenue (see Argentina and FERC). This differentiation allows an opportunity to cross-subsidize dam safety regulation across sectors without over-burdening sectors that are less well off. Such an approach may also be an alternative option for NSW to consider.

Furthermore with regard to the NSW case, there is some indication (from Washington and Queensland) that the proposed regulator resourcing and associated fee model (as determined by CIE, 2020) is appropriate for the regulator role and the number of dams to be supervised. Queensland demonstrates the sort of regulatory efficiencies that can be achieved simply by moving from a government-funded-only system to a user-pays system, whilst South Africa illustrates conditions that would be favourable for adopting user-pays and that would likely alleviate some of its performance issues. However, California and FERC demonstrate that further efficiencies may be possible for NSW. This could potentially reduce the user-pays fee that needs to be charged to dam owners. There is also the option for NSW to consider being less hands-on with its compliance-audit role, such as undertaking audits on a less frequent/scheduled and more random basis (e.g. Victoria and Ontario) which would enable it to supervise more dams with less resourcing/staff and charging lower user-pays fees. Such lower cost/fee options
would be received favourably by dam owners in any jurisdiction provided the purpose of the regulatory framework is not compromised and communities are not put at risk.

Practically, any guidance generated for any country needs to also consider the affordability and collectability of the user pays option. In some revenue-constrained sectors or low-income countries, it may be necessary for government to advocate for continued public sector financing of regulatory mechanisms to ensure suitable standard of care and protection. Also, the non-economic aspects of life and safety, including non-economic value of human life and social and environmental well-being, should also feature within these discussions to ensure a balanced consideration with economics.

At the same time, public sector financing considerations will also be subject to the reality that budget allocation is a political process, and that as productive capacity of any country is limited so is total budget available. This is compounded by the fact that dam failures are typically low probability events and failure of any specific dam, in any specific year, is highly unlikely (with probabilities of once every 50-100 years or longer being involved, see Wishart et al., 2020). Also, estimating the probability of failure of any specific dam is a highly complex and uncertain process. Therefore, politicians and the general public cannot efficiently consider such failures in advance. Furthermore, in jurisdictions that have experienced few failures, the regulatory process or budgetary allocation does not receive any sustained political or public priority/support (Pisaniello, 1997; 2011). There are too many politically and socially important topics where the needs are more certain and clear, such health care and education, that are competing for necessary budgets. Accordingly, it has often been challenging to get policymakers and the general public interested in dam safety assurance, including budget allocation for regulatory processes (Wishart et al., 2020; Pisaniello 1997; 2011). Helping to overcome this challenge and achieve the requisite political will is the flexible regulatory mix, continuum-based approach to dam safety assurance developed by Wishart et al (2020; 2021), as it enables tailoring regulation according to jurisdictional circumstances including political priorities. The procedure developed in this paper offers useful complementary guidance and decision support in the provision of a suitable mix of dam safety regulation funding.

Conclusion

The paper highlights that when dam safety assurance is to be achieved through regulation and an independent oversight authority, effectiveness will be dependent on adequate funding and resourcing of the regulatory authority. The paper identifies the main options for regulatory funding, the pros and cons,
and key circumstantial factors that determine option suitability. The main options comprise user-pays, fully government funded or a mix of these. There is precedent in certain circumstances for adopting a user-pays system on a full cost recovery basis, as there is for adopting a fully government funded system, whilst mixed systems are the most popular. But the institutional design of the authority can also largely determine funding strategy, for example, a national dam safety agency will have a different purview than a state or provincial agency, and both types are represented in the data. Also, other institutions may exist that provide complimentary or supporting roles to the main dam safety regulator under consideration.

Comparative analysis of 15 jurisdicational case studies from around the world representing varying types of regulation and administration along a continuum of dam safety assurance has helped to develop a simple procedure. The procedure identifies increasingly relevant indicative precedents that can guide any particular target jurisdiction on suitable options to fund its dam safety regulation. It allows for consideration of the current or desired resourcing in a target jurisdiction against the key instrument mix in existing regulatory schemes with increasingly relevant and comparable circumstances. The paper has illustrated example application of the procedure to a real case in New South Wales, Australia. The overall findings can be of assistance to jurisdictions looking for different options for a regulatory funding model or require some comparable indicative precedent to support a choice of new model. Also, jurisdictions experiencing poorly implemented dam safety regulation due to inadequate resourcing, staffing and capacity, could find it useful to compare the extent of regulatory funding of other comparable jurisdictions.

The diverse data set of 15 case studies underpinning the procedure provides indicative precedents and guidance from a range of upper-middle and high income countries. These are based on good international industry practices and the availability of data and information on the key proxy determinants of regulatory funding systems, including the role the dam safety regulator performs and the capacity the system supports. While data from lower-middle and low income countries is generally limited, the regulatory funding systems typically rely on public funding through government revenues. The lessons derived from the examples presented herein could therefore be useful in providing indicative options and examples of how to alleviate pressure on limited government revenues and leverage alternative revenue sources to sustain funding and secure the safety of dams and downstream communities.

The systematic procedure proposed herein is based on a simple set of proxy determinants. These include the number of regulated dams per FTE staff that gives little sense of embedded regulatory effort in each area involved in regulation. However, such effort has been captured where possible as part of the role of
the regulator and noted accordingly. The analysis also does not include other factors that may be influential, such as the maturity of the country’s fiscal system, whether any dominant funding model traditions or norms exist, or if any public policy or political priorities are at play. Investigating such factors when information becomes available provides scope for future research, especially in country’s that contain the majority of large dams in the world such as China, India and Brazil. Such countries currently may only generate useful indicative guidance if the simplified proxy determinants are considered satisfactory for their circumstances. Practically, any guidance generated for any country needs to also consider the affordability and collectability of the user pays approach, political priorities with regard to any budget allocation from the public sector, and the non-economic value of human life and social and environmental well-being to ensure a balanced consideration with economics.

Whilst the comparative review of the 15 jurisdictions have provided an adequate platform to generate a foundational data base for the developed procedure, prevailing gaps in some of the data on number of regulated dams per FTE staff limits the richness of the indicative precedent and guidance that can be offered by those cases. Further in-depth investigations in those case study jurisdictions would be necessary to fill those gaps. In effect the diversity and richness of the case studies data set can continue to grow as more jurisdictions develop and more information is made publicly available. This will ensure that the indicative precedents and guidance offered, and the circumstances covered, will also continue to advance. Such advancement would further strengthen the utility of the developed procedure to act as a decision support tool for any government with political will to establish effective, adequately resourced dam safety regulation for the safety of dams and downstream communities.

Acknowledgements

The authors are grateful to the many colleagues who provided valuable feedback, guidance, data and information on the case studies used and updated in this paper. These originated from a global comparative analysis of regulatory frameworks for the safety of dams and downstream communities (Wishart et al, 2020, 2021). Funding for the development of the case studies underlying the assessment and that provide a platform for the novel comparative analyses made in this paper was provided by the World Bank through the Japan-World Bank Program for Mainstreaming Disaster Risk Management in Developing Countries and the Global Water Security & Sanitation Partnership. The findings, interpretations, and conclusions expressed in this paper do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent.
References


Target jurisdiction key characteristics

**1 Funding option**
- User pays
- Government funding
- Mixed

**2 Regulator role**
- Random audit
- Quality assurance
- Directed

**3 Regulator capacity**
- Number of regulated dams
- Number of FTS staff (including any funded board members)

Level and strength of indicative precedent/guidance

**A. Highest/strongest indicative precedent** from jurisdictions with coincidence of:
- 1 mostly matching
- 2
- 3 (i) if possible/available

**B. Considerable indicative precedent** from jurisdictions with coincidence of:
- 1 main option matches but not an exact match or sub-option (eg levy vs. user fee for service instead of levy)
- 2
- 3 (i)
- 3 (ii) if possible/available

**C. Moderate indicative precedent** from jurisdictions with coincidence of:
- 1 any match
- 3 (i)
- 3 (ii) if possible/available

**D. Lowest/weakest indicative precedent** but possibly useful guidance from jurisdictions with coincidence of:
- 2
- 3 (i)
- 3 (ii) if possible/available

Dam Safety Regulatory Funding Decision Support Tool: Comparative jurisdiction results matrix identifying key indicative precedents/guidance relevant to the target jurisdiction in descending order of indicative precedent/guidance strength
Funding dam safety regulation: an international comparative analysis and example application in Australia

SUPPLEMENTARY MATERIALS

SUPPLEMENTARY MATERIAL A

International review of 15 case study jurisdictions with focus on dam safety regulatory funding

The findings of the global comparative analysis of regulatory frameworks for the safety of dams and downstream communities (Wishart et al., 2020) as discussed within this paper, enable here a more focused international review to be undertaken on dam safety regulation funding. Wishart et al (2020) undertook detailed case studies of 51 countries (that are estimated to account for more than 95% of the world’s large dams) with regard to their regulatory frameworks, including their institutional and financial arrangements which are relevant to this paper (see Wishart et al., 2020: Appendix B for the extent of information sought for each case study). The 51 case studies drew on global data sets, publicly available information, the input of World Bank specialists and other international and national experts, formal peer review, and consultations with professional bodies (Wishart et al., 2020).

The following sections present key information and data for the 15 case study jurisdictions reviewed for this paper; being those that offer the richest information and data on dam safety regulation funding based mostly on the findings of the Wishart et al. (2020) global study but updated where possible. Each review pays particular attention to how dam safety regulation is funded (including what main option/sub-option is adopted) and the two key circumstantial factors identified in the paper (namely the role that the dam safety regulator performs and the capacity that the regulatory system supports). Any other unique options, circumstances or lessons that emerge from the review are also noted. The case study reviews are presented arbitrarily in turn below to enable the comparative analysis within the paper for identifying useful specific trends, indicative precedents and guidance on dam safety regulatory funding and the dependent circumstances.
1. Victoria

In Victoria there are 19 state-owned water corporations covering urban and rural sectors who own the bulk of the state’s 106 large dams (Perera and Arnold, 2016; DEPI, 2014, Victoria State Government, 2021). These are directed by the Essential Services Commission Act 2001, the Water Industry Regulatory Order 2003, the Water Industry Act 1994 (which creates the right for the Minister for Water to issue Statements of Obligations (SoO) to the State’s Water Corporations on matters including dam safety), Ministerial Guidelines on ‘Policies for Managing Works Licences’ 2016, all overarched by the Victorian Water Act 1989. The institutional arrangements can be complex and so the focus necessarily has been on setting of water prices as a sustainable revenue stream for publicly owned water corporations, and on how they can recover expenditure on renewing and rehabilitating assets (Cooper et al., 2014). Safety mechanisms are strong but resourcing adequate oversight has been a secondary concern (Ram et al., 2021).

The role of the dam safety regulator, Department of Environment, Land Water and Planning (DELWP) in Victoria is compliance-audit and very hands-off (per Figure 1 in the paper). Currently no dam safety audits are done by DELWP (Ram et al., 2021). But there is some quality assurance role simply because the regulator does collect, monitor and reports on information it collects as part of its quality assurance for public water corporation dams. DELWP is fully government funded. It has approximately 1.5 FTE staff in the DELWP main office to supervise almost 10,000 dams (Ram et al., 2021). For private dams licencing fees are paid by private dam owners to Licencing Authorities (delegates of DELWP) which contributes to the administration of the dam safety regulation related to private dams only (Victoria State Government, 2021). A recent review of Victoria’s dam safety regulatory framework commissioned by the State Government found that whilst it’s approach to regulatory funding has worked reasonably well to date for providing an oversight framework that is generally consistent with good practice in Australia and internationally, it unfortunately has not enabled the dam safety regulator to perform some basic fundamental oversight roles including conducting audits (not even on a random basis) and maintaining a publicly available consolidated register of regulated dams (Ram et al., 2021).

2. Tasmania

The regulator is quite hands-on with regard to hazard assessment and checking of surveillance reports. Tasmania has a good equitable user-pays system which gains its power from the Water Management Act 1999. There is no fee for registering dams. The policy looks to have all existing dams registered; any new dams are registered when they are granted a permit and the permit application fee covers this. Fees for permits are set by the Water Management (Safety of Dams) Regulations 2015 per Schedule 4, Part 2 based
on an incremental fee structure as follows:

- Current fees are: 381 fee units plus:
- 54 fee units for each hour spent in processing the application (excluding the first 7 hours); and
- 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
- 421 fee units where the assessment is made by the current equivalent of the former Assessment Committee.
- Fee units are currently worth AU$1.65 (2021/2022). Fee units are reviewed annually and usually increased to keep pace with inflation (Government of Tasmania, 2021).

The Regulations also require that dam owners pay a fee to the regulator for assessing design, construction, maintenance, surveillance or decommissioning reports in respect of one or more dams as follows: 25 fee units for the first dam; and 20 fee units for each 0.5 h spent in assessing the report – but not exceeding a total of 250 fee units. This, together with the incremental fee structure for permits, provides an innovative and equitable user-pays type method for subsidising the dam-safety assurance policy in Tasmania. FTE staff are approximately 3 in the main office – given 10,000+ dams currently regulated this is an unmanageable number, even over a relatively small landmass. However, regional water management offices do have some involvement.

3. Queensland

The role of the regulator (DNRME) is considerably hands-on as it takes on the responsibility to make failure impact assessments for the majority of dams in the state (ie the thousands that do not meet the regulatory large baseline size capture criteria) in forming ‘reasonable belief’ that there is a Population at Risk (PAR) for regulatory capture purposes. There are dam safety authorised officers within DNRME whose general function is to monitor and enforce compliance with dam safety regulations which requires them to undertake regular inspections of referable dams. Dam safety regulation and administration is fully Government funded. Interestingly, there is provision in the legislation for government to exercise the power to charge users - however the focus has been more on compliance so far. The dam safety regulator for water supply dams in DNRME currently regulates 108 dams and has 18 FTEs: 10 are engineers and, of these, 6 are RPEQ; 3 are communications / disaster response specialists and 5 are quality control, IT and administrative support. Above the FTE costs QLD have annual budget allocations for travel, IT support, etc. Also receive additional budget allocations to support specific projects associated with regulatory
responsibilities. This varies year on year and according to need (and financial constraints and priorities of the broader divisions in which the dam safety team sit). Current financial year additional budget for specific projects is around $250,000.

4. New Zealand

The Regional Authorities have broad supervisory/quality assurance/audit type powers to ensure accepted dam safety management standards are being applied by dam owners and their engineers. Dam safety assurance regulator’s roles and responsibility proposed to be established under the Building Act but the necessary dam safety regulatory framework is yet to be developed/implemented. The Regulator is expected under the Building Act dam safety scheme to receive documentation of dam safety management activities from the dam owner, rather than act as a “hands on” inspection agency. The extent to which the New Zealand dam safety scheme is user-pays and/or funded from government’s general revenue cannot be ascertained as the scheme is yet to be implemented in practice. The current scheme in regard to building consents for new development or alteration of “large dams” – ie treating dams as buildings – is funded via a user-pays licence/consent/certification system.

5. United Kingdom

Formerly under the Reservoirs Act 1975 enforcement throughout the UK was via local county councils under one centralized oversight authority being the Environment Agency. But this resulted in inconsistent application of the Act amongst the various county councils. Now the Reservoirs Act 1975 has been decentralized so that essentially only England and Wales are subject to the 1975 Act (as amended to enable separate administration in each country) whilst Scotland and Northern Ireland have enacted new but similar local versions of the Act being the Reservoirs (Scotland) Act 2011 and Reservoirs Act 2015 (Northern Ireland). This has enabled oversight and enforcement of the Reservoirs Act to be made more centralised in each of the 4 countries via:

- England: Environment Agency (EA)
- Wales: Natural Resources Wales (NRW)
- Scotland: Scottish Environment Protection Agency (SEPA)
- Northern Ireland: Dept. of Agriculture and Rural Development (DARD)

Despite this “decentralizing” of the Reservoirs Act 1975 it substantively remains the principal legislation in each of the four countries with regard to the minimum standards for the construction, supervision, maintenance, inspection and decommissioning activities. The same system of panel engineers is used as in England.
The role of each oversight authority is essentially a compliance audit/quality assurance role. Each authority is responsible for assigning the ‘risk designation’ of the reservoir (e.g. see Flood and Water Management Act 2010 Schedule 4, s.7 for England and Wales, and SEPA (2019) website for Scotland). Dams as small as 25 ML in capacity were captured/registered for regulation under the original Reservoirs Act 1975 but now under the decentralised model Wales, Scotland and Northern Ireland capture dams as small as 10 ML. However in each country there is now also consideration given to the risk designation for determining which registered dams are subjected to higher standards and oversight, eg in England and Wales only High Risk dams, in Scotland and Northern Ireland both High and Medium Risk dams.

The above 4 dam safety regulators are fully or partially funded by their respective governments. For example, EA does source revenue from environmental licence fees. In Wales, fees by the oversight authority have recently been introduced for the first time. These include a once off registration fee of £510 and for high-risk reservoirs only an annual subsistence fee/levy of £230 (NRW, 2017). In Scotland the Reservoirs (Scotland) Act 2011 sections 14 and 23 give Scottish Ministers the power to make provisions for SEPA to recover the direct regulatory and administrative costs of carrying out SEPA’s duties in relation to controlled reservoirs. Under this power SEPA (2021) currently charges dam owners a once off registration fee of £569 and an annual subsistence fee/levy of £473 for High risk reservoirs, £318 for Medium risk and £194 for Low risk reservoirs. Also if a dam owner requests a review of the risk designation made by SEPA a fee of £400 is charged. As for the works undertaken by independent Inspecting engineers (i.e. Panel engineers), it is the dam owner that is required to consult these engineers after selecting them from the Panel register, a government approved register maintained by the Environment Agency for England and Wales and the respective reservoir safety agencies for Scotland and Northern Ireland (see UK Government, 2021 for details on England, Wales and Scotland, and Section 102 of the Reservoirs (Northern Ireland) Act 2015 for details on Northern Ireland). Hence, the associated consulting fees are the responsibility of the owner, making this component of the UK’s dam safety regulation a unique form of user-pays oversight.

In England there are 2097 dams registered as of December 2020, with 1588 of these being ‘High Risk’ and so subjected to higher standards and oversight (EA, 2021). There is no data available on the level of funding/resourcing the Environment Agency works with to perform its dam safety oversight role. In Wales there are 371 dams registered as of March 2021 and there is no data available on the level of
funding/resourcing NRW works with to perform its dam safety oversight role (NRW, 2021). Neither registered dams or oversight capacity data could be sourced for Scotland and Northern Ireland from current public sources.

6. Portugal

The Portuguese Environment Agency (APA), from the Portuguese Ministry of the Environment acts as the National Dam Safety Authority under Decree Law 21/2018, having general competence in supervising the owners’ compliance with the Regulations. There is a quality assurance type supervisory role to ensure accepted dam safety management standards are applied by dam owners and their engineers, but the regulatory inspections and standards checked against are quite specific and directive as they are codified (Civil Law system) dam safety standards. According to Article 10 of the 2018 Decree: Expenditure resulting from the activities of Government authorities involved in the control of dam safety by means of allocation to this Regulation, shall be borne by the developer (ie dam owner), in an annual amount that depends on phase of the work, the associated potential damage and the size and type of work, which will appear in a table to be published by order of the members of the Government responsible for the areas of public works and the environment. There are 716 dams regulated in Portugal but no information is readily available on regulator resourcing/staffing.

7. Norway

The Norwegian Water Resources and Energy Directorate (NVE) is the dam safety authority in Norway, it has broad supervisory/quality assurance/audit type powers and is responsible for ensuring that the dam owners comply with the requirements given in the law and regulations. NVE’s tasks include:

- Approval of classification
- Approval of qualifications – dam owners and consultants
- Approval of flood calculations
- Approval of safety documents
- Approval of plans – new dams or rehabilitation/renewal
- Control/approval of re-assessments
- Audit of the internal control systems of the dam owners (including inspection on site)
- Development of regulations and guidelines
- Updating the public dam register
- Information about dams and dam safety
- Inspection of sites during construction
Random inspection of sites during operation

One hundred per cent of the related costs are financed by the dam owners. For funding the regulator, dam owners pay an annual fee to the dam safety authority (NVE) for the governmental supervision which includes; approval of documents, audits, inspections, development of guidelines etc. The fee is set on the basis of dam height, dam consequence class and reservoir volume. All dams (over 6000) are captured but the requirements are adjusted to the consequence classes, therefore the more stringent requirements are given to dams in the highest consequence class. But no information is readily available on regulator resourcing/staffing.

8. Alberta (Canada)

Alberta Environment and Parks (AEP) is the dam safety regulator. AEP has broad supervisory/quality assurance/audit type powers and its role includes:

- On-Going Monitoring and Compliance Assurance. This includes ensuring that dam owners submit their mandatory regulatory compliance reporting (on plans and operation, safety assessments and evaluations, and safety directives), and performing audit inspections annually for safety assessment of the structures and to ensure compliance with Part 6 of the Water (Ministerial) Regulation.

- Deficiency Tracking and Follow-ups. The Dam Safety Team tracks all dam safety deficiencies identified based on required regulatory reporting, safety assessments and evaluation, and audit inspections.

Funding is via licence fees and from general government revenue allocations. The AEP Dam Safety team had 10 FTEs by end of 2017, supervising over 1500 dams. An audit of the dam safety regulatory system was undertaken by the Auditor General of Alberta in March 2015. The audit found that despite Alberta having a good workable dam safety regulatory framework in place, it also found that the regulator was doing a poor job at implementing and administering the regulation (CBC News, 2015).

9. Ontario (Canada)

There are 3300 dams in Ontario and most of these require at least regulatory approval. The dam safety regulator in Ontario is the Ministry of Natural Resources and Forestry which administers the Lakes and Rivers Improvement Act 1990 that has the purpose of protection of persons and of property by ensuring that dams are suitably located, constructed, operated and maintained and are of an appropriate nature.

The Ministry undertakes:

- processing in a consistent manner, applications submitted under LRIA Section 14 or 16
- issuing or refusing approvals under LRIA Section 14, 16, 17.2 or 23.1
- undertaking educational initiatives to explain the purpose of the LRIA and its associated regulations
and

- conducting periodic compliance monitoring for hazardous dams (e.g. inspections, selective reviews and investigations) and enforcement (including Minister’s Orders) to ensure the intent of the LRIA is being met.

The Act sets up a function for the Minister to set, charge and collect fees for issuing dam safety approvals under Sched. I, s. 29. But no information is readily available on regulator resourcing/staffing.

10. California (USA)

California Department of Water Resources (the dam safety regulator) is a dam safety office within a more general Government department. The regulator is very hands-on and conducts its own inspections and reviews of the dams. All of the 1250 dams under the jurisdiction of the Division are inspected at least once per year and monitored for changes. California recovers the large proportion of their funding through fees charged to dam owners (based on the height of the dam) which covers almost the entire cost of the regulations (fee and permit approval fees). There are 1250 dams regulated by 60 FTE staff.

11. Washington (USA)

The statutes provide the Department of Ecology, Dam Safety Section, with wide powers to regulate and control the safety of dams. These are more hands-on powers to undertake assessments and checks against code-like standards. The dam safety authority by taking a more hands-on ‘direct surveillance’ approach (rather than a compliance/audit role, see Figure 1) it may also take on some responsibility for that surveillance and hence some potential liability if a dam fails. There is a user pays system in place including inspection/consultant-like fees. There are 111 dams regulated by 9FTE regulator staff.

12. FERC (USA)

The Federal Energy Regulatory Commission (FERC) does not own any dams but regulates all non-Federal hydroelectric projects in the USA. There are over 2,500 dams regulated by the Commission. FERC’s role is one of direct surveillance, i.e. very hands-on. As of 2016, there were 132 technical and support staff in the FERC Division of Dam Safety and Inspections. FERC receives money from Congress, but recovers all of this through the collection of annual charges and filing fees. FERC does not charge the licensees and exempts fees for performing dam safety inspections at their projects. Fees are collected through the licensing process and annually they are charged for “headwater benefits”. The fees collected annually are paid to the U.S. Treasury and are more than enough to pay the annual hydro budget of the FERC
13. South Africa

The Dam Safety Office (DSO) within the Department of Water and Sanitation (DWS) is made responsible by the Minister under the Water Act 1998 to administer the Safety of Dams Regulations 2012. The DSO has supervisory/quality assurance/compliance-audit type powers to ensure accepted dam safety management standards are applied by dam owners and their APPs (engineers). Over 5000 dams are currently regulated. However, the system does give the regulator the role of categorising the dams per s.121 of the Act and s.2(4) of the Regulations, and so ultimately the regulator is also responsible (and potentially liable) for performing this role. The scheme is fully covered by Government’s general revenue. The Water Act makes provision for licencing fees but this has not been utilised – a policy decision has been taken by the regulator that this should be a function of government and not of dam owners. In 2015 the DSO had a total budget of ZAR 7 483 000 and a total of 14 FTE staff were in charge of dam safety regulation at its headquarters and regional offices (Department of Water and Sanitation, 2015, p.1,3). A 2016 detailed self-performance assessment of the dam safety regulatory scheme found that “The regulatory system rely on reminders and instruction letters from the Dam Safety Office when the first and the next dam safety evaluation must be submitted. The administrative capacity of the Dam Safety Office has never been adequate to perform this task at the required level. The technical capacity of the Dam Safety Office has also never been adequate to evaluate all the reports received timeously and to adequately guide the process of compliance monitoring and to decide when the next evaluations must be performed” (van den Berg, 2016). This suggests that perhaps the South Africa regulator should move more towards a user-pays system by using its existing power under the Water Act to charge licencing fees.

14. Sweden

There are an estimated 10,000 dams in Sweden of varying size, type and age. Independent of their size, purpose and consequences of dam failure all dams are regulated under the Environmental Code and associated Dam Safety Ordinance 2014. But only about 500 dam facilities include one or more dams where a dam failure would result in significant damages such as loss of human life and health and/or serious damage to the environment, infrastructure or services vital to society and/or major economic damage. These dams are assigned a dam safety class A, B or C and are made subject to the more stringent requirements of the regulation and associated oversight. Svenska kraftnät (Swedish National Grid Agency) has the function as a national authority for dam safety. The tasks include promoting dam safety in Sweden, acting for research, development and capacity building, and acting for emergency preparedness for dam failure and floods in regulated rivers. The role is also to issue regulations and guidelines under the dam safety ordinance, and provide supervision guidance on issues related to dam safety to the regional
supervisory authorities - the county Administrative Boards. In practice, supervisory guidance includes
development of uniform routines for dam safety supervision, to coordinate, follow-up and evaluate the
supervision as well as to provide advice and support to the regional supervisory authorities. The dam
safety assurance authority (and administering regional authorities) simply empowered to provide broad
supervisory/quality assurance/audit type role to ensure accepted dam safety management standards
applied by dam owners and their engineers. Since 2016 the dam owner pays an annual fee to the
supervisory authority for classified dams; Dam safety class A: 96 000 SEK/year (10 Sek = approx. 1 Euro.),
B: 36 000 SEK/year, C: 6400 SEK/year. On demand an additional fee of 800 SEK/hour can be charged for
relevant supervision. No information is readily available on regulator resourcing/staffing.

15. Argentina

The regulator Organismo Regulador de Seguridad de Presas (ORSEP) is responsible for the technical
regulatory functions and the supervision of the structural safety of all national dams (per Decree No.
239/99). Only 31 of the large dams in Argentina are currently regulated and hence supervised by ORSEP,
these being all privatized hydro dams. ORSEP expenses are financed with contributions from the National
Treasury and a tax on hydroelectric generation, as stated in concession contracts. No information is readily
available on regulator resourcing/staffing.
SUPPLEMENTARY MATERIAL B

Illustrative Application Case Jurisdiction: New South Wales (NSW) Dams Safety Regulation and Funding

The following details the illustrative live case jurisdiction of NSW and the current and proposed approach to regulatory funding. This information is used to apply the simple procedure developed in the paper to generate relevant precedents/guidance discussed therein in order to illustrate how government decision making on regulatory funding can be supported.

NSW is the only state in Australia to have specific dam safety legislation, that is the Dams Safety Act is an Act of parliament dedicated specifically to dam safety. The NSW Government in 2013 commissioned a review of the Dams Safety Act 1978 and the Dams Safety Committee that implemented it. The review was undertaken by consultancy firm KPMG and in consultation with key stakeholders within the NSW dam industry. The review made 14 recommendations to the NSW Government about how to best improve the safety regulation of dams. Based on the recommendations of the KPMG review, the new dams safety legislation, the Dams Safety Act 2015, was developed and was passed in September 2015. (NSW DoI,, 2019). The changes contained in the Dams Safety Act 2015 (which were triggered in November 2019 when the Dams Safety Regulation 2019 and associated standards were also passed under the empowerment of this Act) replace the previous system with a more modern, community risk management and cost-benefit analysis approach.

The new 2015 Act replaces the former Dams Safety Committee (DSC) with Dams Safety NSW. The former DSC’s role was more quality assurance and hands-on, where the DSC closely checked and directed many dam owner’s safety and risk management decisions and ultimately assumed much residual responsibility and potential liability for those decisions. To eliminate this potential residual liability the role of the current regulator, Dams Safety NSW, is now more towards being compliance-audit and hands-off as is further reinforced below.
The former system was funded solely by state government from general revenue. The new system is looking to be more user-pays per s.41 of the 2015 Act where regulations can make provision for charging dam owners a “dam safety levy”. The Regulation 2019 has not included to date the charging of any such levy, but the power is there to do so at any time. In mid-2020 the NSW government decided to explore this option of funding the dams safety regulatory system via user-pays when Dams Safety NSW published a proposed user pays pricing levy to be applied to regulated NSW dam owners for comment. The details of the proposed levy and the investigations into options for cost-recovery are outlined in a report by the Centre for International Economics (CIE, 2020). A brief outline of the proposal from CIE (2020) follows. It is proposed to recover $4.0m of the total operational budget of $4.6m in annual costs with the use of an annual levy based on the ownership of the number of dams in different consequence categories (Table SM1). Hence, this proposed regulatory funding system can be considered to be predominantly user-pays through the levy.

Table SM1. The NSW proposed annual levy structure (after CIE, 2020, p.3)

<table>
<thead>
<tr>
<th>Consequence category</th>
<th>First dam $ per year</th>
<th>Subsequent dams $ per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme</td>
<td>16 923</td>
<td>11 846</td>
</tr>
<tr>
<td>High A</td>
<td>14 992</td>
<td>10 494</td>
</tr>
<tr>
<td>High B</td>
<td>14 992</td>
<td>10 494</td>
</tr>
<tr>
<td>High C</td>
<td>14 992</td>
<td>10 494</td>
</tr>
<tr>
<td>Significant</td>
<td>9 094</td>
<td>6 366</td>
</tr>
<tr>
<td>Low</td>
<td>5 048</td>
<td>3 534</td>
</tr>
</tbody>
</table>

CIE (2020) lists Dams Safety NSW activities that need to be funded as:

- The declaration of new dams
- Reading and processing annual dams safety standards reports
- Providing mining authority consents
- Conducting periodic compliance audits
- Education and policy activities to administer the regulatory framework
- Program and systems management

These activities reinforce that the role of Dams Safety NSW is more towards being compliance-audit and hands-off but still with some quality assurance function, eg scheduled periodic audits rather than random.
The capacity that the proposed regulatory funding system is intended to support is around 400 regulated
dams with 22.5 FTE staff and 5 Board members (CIE, 2020).

Considerations by the NSW Government to implement the proposed levy system have currently been
paused as “at this time would not be appropriate” due to dam owner feedback highlighting “recent
challenges faced....including bushfires, floods and the pandemic” (Dams Safety NSW, 2021). Hence, with
government considerations on pause in this way, NSW provides an ideal example live case to illustrate
application of the simple procedure developed in the paper (per Figure 2).

To this end, the above data on the 3 key determinants used in the Figure 2 procedure for NSW is presented
and analysed in the following section (see especially Table SM2).
SUPPLEMENTARY MATERIAL C

Illustrative Application of the Developed Procedure: Assessment of the Level of Coincidence of Comparable Jurisdictions with the Example Case of NSW

In applying the Figure 2 procedure to the case of NSW, the level and strength of precedent/guidance represented by the comparable schemes is dependent on the level of coincidence amongst these 3 key determinants as detailed in Figure 2, Precedent Strength A - D. This level of coincidence with NSW can be assessed as follows.

Per international review and comparative analysis findings in Tables 1 - 3, 7/15 jurisdictions adopt either a user-pays or mixed regulatory funding mechanism so as to be relevant to the scheme being proposed for NSW (Table 1) and include Tasmania, UK, Portugal, Norway, Alberta, Sweden and Argentina. From Table 2 each of these 7 jurisdictions have a regulator role of compliance audit/quality assurance that can be regarded similar to NSW. Of these 7 jurisdictions, 5 are the most relevant, namely Portugal, Norway, Sweden, UK and Argentina, which adopt some sort of general dam safety fee, levy or tax similar to that being proposed for NSW.

From Table 3, whilst these 5/7 most relevant jurisdictions have information readily available on the number of dams that they regulate, unfortunately only the UK (England and Wales) has information readily available on the regulator resourcing/staffing that is supported by the funding scheme. Nevertheless these 4 highly relevant jurisdictions (Portugal, Norway, Sweden and Argentina) may still provide some useful indicative precedents for NSW, whilst the other 2/7 (Tasmania and Alberta) may provide some indicative precedents/guidance on other options for regulator funding that is based on some sort of user-pays, especially as these also have information on regulator resourcing/staffing available (Table 3).

From the remaining jurisdictions, 6 do not have a regulator role that is in line with NSW (ie either less or more hands-on per Table 2) but they do adopt some sort of user-pays mechanism (Table 1). Whilst these 6 jurisdictions do not necessarily provide comparable precedent they may still provide some indicative guidance/lessons to NSW, especially as most offer regulator resourcing/staffing data (Table 3). These jurisdictions include Victoria, New Zealand, Ontario, California, Washington and FERC.
The remaining 2 jurisdictions, Queensland and South Africa, provide the weakest comparable precedent to NSW as these are fully government funded with no user-pays (Table 1) but because the regulator role is comparable (Table 2) they are still worth considering as they may provide some sort of merit or otherwise with regard to a fully government funded system which is what NSW has been operating with to date.

Table SM2 demonstrates NSW compared to the reviewed jurisdictions in descending order of precedent/guidance strength representing the key output matrix of the Figure 2 procedure. A summary of the key information that is available on the funding schemes for each of the jurisdictions in Table SM2 is provided in the paper under section titled “Illustrative application to determining an appropriate funding system for dam safety in New South Wales, Australia”, grouped from precedent strength A to D for NSW in line with the Figure 2 procedure.
Table SM2: NSW Comparison : Application and end result matrix of the procedure in Figure 2 to NSW

<table>
<thead>
<tr>
<th>Financing of regulator</th>
<th>Role of regulator</th>
<th>Internal capacity of regulator/system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government funded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>User-pays</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of user-pays</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Registration/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>License/permit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>fees for service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inspection/review</td>
<td></td>
</tr>
<tr>
<td></td>
<td>fees for service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other eg general</td>
<td></td>
</tr>
<tr>
<td></td>
<td>dam safety fees,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>levy, tax</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compliance audit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compliance audit/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>quality assurance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct surveillance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regulated Dams/FTE Staff</td>
<td></td>
</tr>
</tbody>
</table>

**NSW**

A. HIGHEST/ STRONGEST INDICATIVE PRECEDENT

<table>
<thead>
<tr>
<th>Country</th>
<th>FTE Staff</th>
<th>Dams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td></td>
<td>716</td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td>6000+</td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td>10,000 (500 high consequence more closely regulated)</td>
</tr>
<tr>
<td>UK</td>
<td></td>
<td>2097 dams (England); 371 dams (Wales)</td>
</tr>
<tr>
<td>Argentina</td>
<td></td>
<td>31 dams (hydro only)</td>
</tr>
</tbody>
</table>

B. CONSIDERABLE INDICATIVE PRECEDENT

<table>
<thead>
<tr>
<th>Country</th>
<th>FTE Staff</th>
<th>Dams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tas</td>
<td></td>
<td>10,000 dams / 3 FTE</td>
</tr>
<tr>
<td>Alberta</td>
<td></td>
<td>1500+ dams / 10FTE</td>
</tr>
</tbody>
</table>

C. MODERATE INDICATIVE PRECEDENT

<table>
<thead>
<tr>
<th>Country</th>
<th>FTE Staff</th>
<th>Dams</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIC</td>
<td></td>
<td>8300+ dams / 1.5 FTE</td>
</tr>
<tr>
<td>NZ</td>
<td></td>
<td>Regulatory framework not yet developed/implemented</td>
</tr>
<tr>
<td>Ontario</td>
<td></td>
<td>3000+ dams</td>
</tr>
<tr>
<td>California</td>
<td></td>
<td>1254 dams / 60FTE</td>
</tr>
<tr>
<td>Washington</td>
<td></td>
<td>111 dams / 9FTE</td>
</tr>
<tr>
<td>FERC</td>
<td></td>
<td>2525 dams / 132FTE</td>
</tr>
</tbody>
</table>

D. LOWEST/WEAKEST INDICATIVE PRECEDENT

<table>
<thead>
<tr>
<th>Country</th>
<th>FTE Staff</th>
<th>Dams</th>
</tr>
</thead>
<tbody>
<tr>
<td>QLD</td>
<td></td>
<td>108 dams / 18 FTE</td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
<td>5000+ / 14 FTE</td>
</tr>
</tbody>
</table>

*The proposed system for NSW is predominantly a ‘user-pays’ general dam safety levy supplemented with minor government funding, however the current system is fully government funded.

**Before the Dams Safety Regulation 2019 the DSC operated on an annual budget of around $2M, with 378 regulated dams / 11FTE + 9 DSC.

***As per the underpinning regulatory system of “Panel Engineers” provided for under the original Reservoirs Act which prevails consistently amongst the four countries’ current regulations representing a unique form of user pays independent oversight within the UK. Also as per Scotland which charges a fixed fee when a dam owner requests a review of the regulator’s risk designation.

****As per the annual subsistence fee/levy charged in both Wales and Scotland. In Scotland the amount of this fee/levy increases with the Risk Designation of the dam.
References to Supplementary Materials

CBC News (2015) ‘Alberta poor at regulating dam safety, auditor general says’


