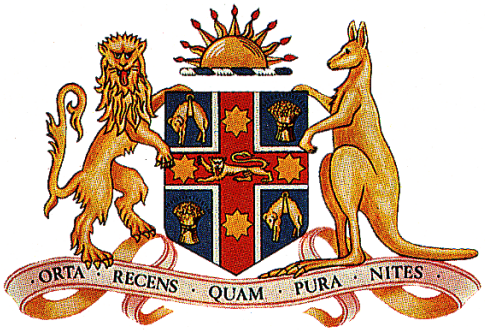

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Natural Resources Access Regulator

Dams Safety New South Wales

Societal and individual risk rating methodology

for

Dams Safety Act 2015

Contents

Part 1 Preliminary

1 Background

The Dams Safety Regulation 2019 requires that an owner of a declared dam must calculate the societal and individual risk rating of the dam (or proposed dam) in accordance with this methodology.

Part 2 Dam societal and individual risk rating calculation for an existing or proposed declared dam

2 Societal risk rating

(1) As part of the risk management framework, all foreseeable dam failure scenarios (or credible modes of failure) that involve potential fatalities must be identified and a societal risks calculated for each scenario. The societal risk rating is then determined as follows:

Societal risk rating = Fn x N

Where:

F_n is the *estimated annual probability of failure of a dam with the best estimate loss of life ≥ N*

N is the estimated number of fatalities due to dam failure

(2) In determining the societal risk rating, F-N is plotted on either Figure 1 or Figure 2, for existing dams and for proposed dams or major augmentations respectively. The Figures also depict the safety threshold graphically.

(3) The societal risk rating to be used must be the highest value of those societal risks calculated in 2 (1) above.

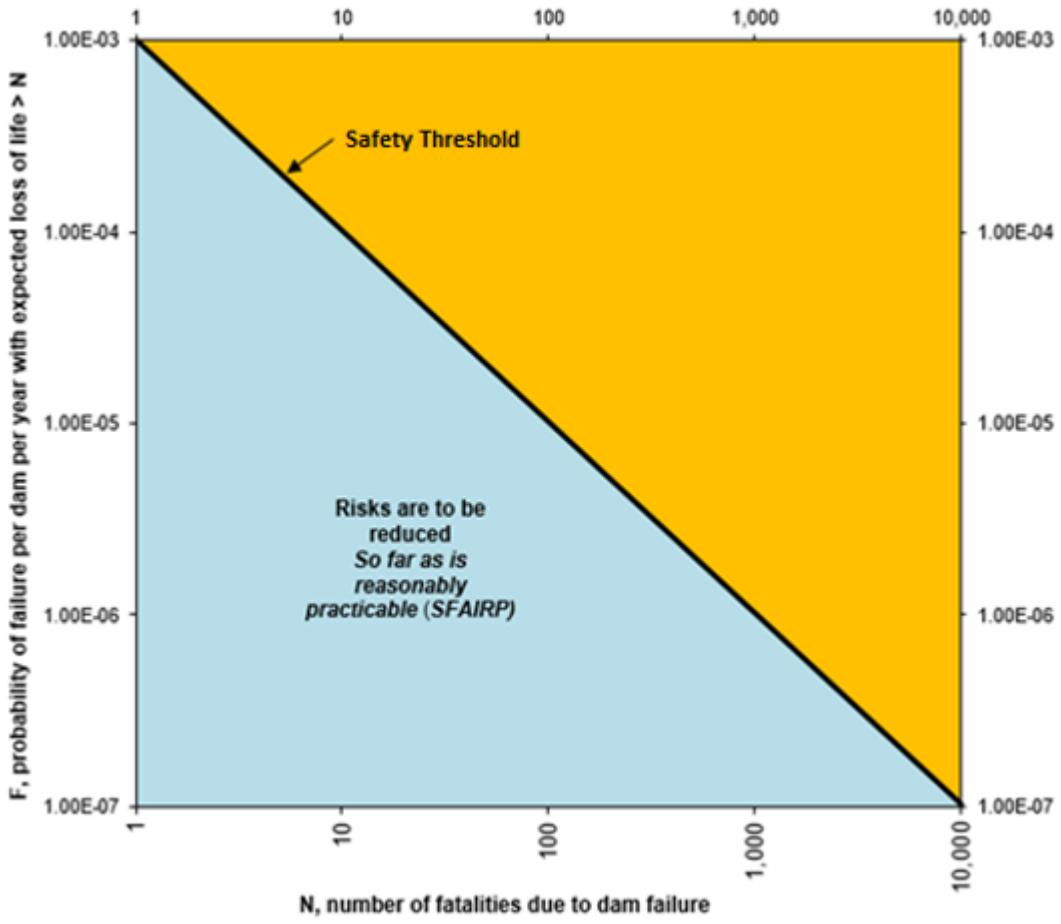

Figure 1. Societal safety threshold for existing dams

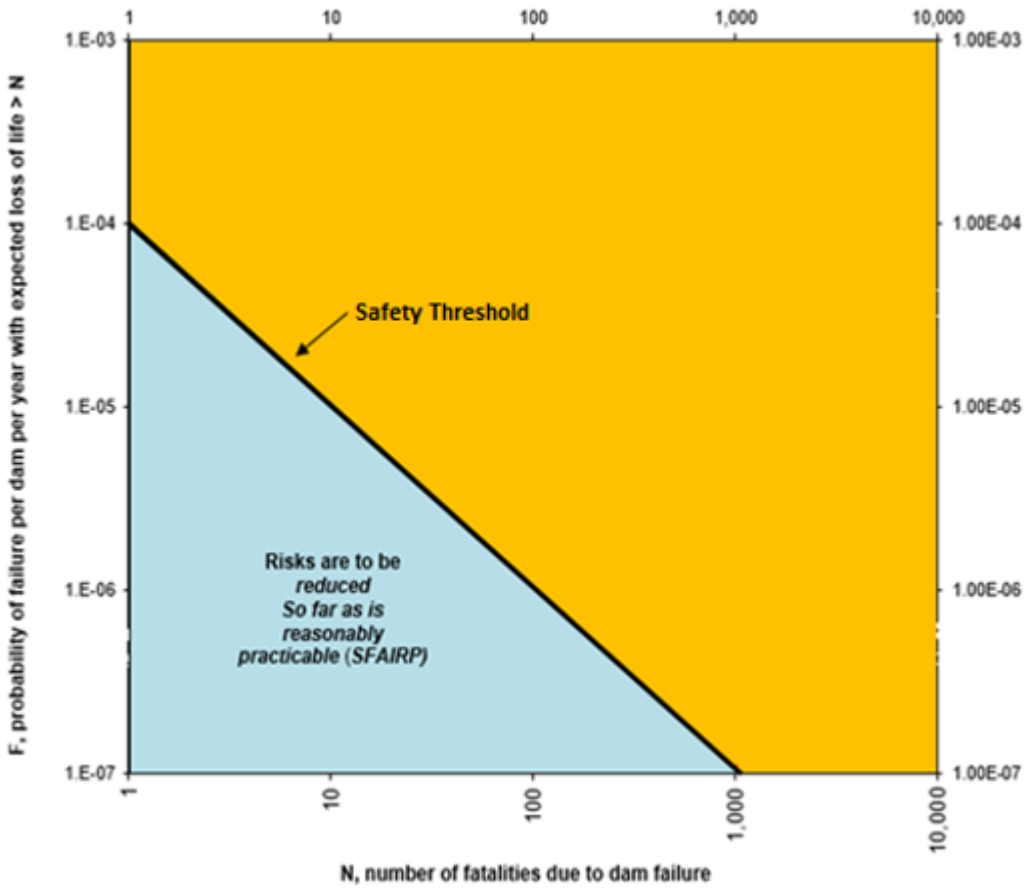

Figure 2. Societal safety threshold for proposed dams and major augmentations to existing dams

3 Individual risk rating

(1) An individual risk rating must be determined for the dam and is defined as the increment of risk to the life of the person because of the dam.

Note: Exposure of a person at a particular location needs to be taken into account, being the closest within the inundation area to the dam may not automatically mean that person is at the “most risk”.

4 Determination of estimated annual probability of failure of a dam

(1) All foreseeable hazards and failure scenarios adversely affecting the safety of the dam must be identified.

(2) The estimated annual probability of failure of the dam, F_n, must be calculated as a result of quantitative risk analysis involving accepted methods related to each failure scenario. Accepted methods include historical performance and event tree analyses.

(3) Other methods recommended by ANCOLD may also be used, or other alternative methods accepted by a competent person.

5 Determination of the estimated number of fatalities due to dam failure

The number of fatalities due to dam failure must be calculated using the following method:

(1) determine the dam failure scenarios that will be evaluated (loss of life estimates are needed for both failure of the dam during normal weather conditions and failure of the dam during flood conditions),

(2) determine time categories for which loss of life estimates are needed (the number of people at risk downstream may be influenced by seasonality, day of week, or time of day factors),

(3) determine when dam failure warnings would be initiated (analysis of dam failure warning times and how they would affect loss of life),

(4) determine area flooded for each dam failure scenario,

(5) estimate the number of people at risk for each dam failure scenario and time category,

(6) apply empirically-based equations or methods for estimating the number of fatalities, and

(7) evaluate the uncertainty associated with the determination of the number of fatalities.

6 Acceptable methods for calculation of the estimated number of fatalities due to dam failure

The methods described in the following are acceptable methods for calculation of the number of fatalities estimated due to dam failure, in accordance with section 5:

(1) Graham, W J, 1999, *A Procedure for Estimating Loss of Life Caused by Dam Failure*, DSO-99-06, U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado. https://www.usbr.gov/ssle/damsafety/TechDev/DSOTechDev/DSO-99-06.pdf

When using Graham's method for estimating loss of life, the criterion boundary from low to medium flood severity should be D ≥ 3m and DV ≥ 4.6m2/s. The criterion boundary from medium to high flood severity should be DV ≥ 15m2/s and the maximum rate of rise ≥ 3m per 5 minute period (i.e. too rapidly to allow people a reasonable chance to escape).

(2) United States Bureau of Reclamation (USBR), *RCEM – Reclamation Consequence Estimating Methodology (2015): Guidelines for Estimating Life Loss for Dam Safety Risk Analysis*.

(3) Developed and already-applied software modelling systems that involve spatially-distributed, dynamic simulations for estimating potential loss of life (PLL) loss from natural and dam failure floods; particularly for very large and high or extreme consequence category dams with an expected large estimated loss of life.

(4) Other methods recommended by ANCOLD may also be used, or other alternative methods accepted by a competent person.

(n2019-2517)

Natural Resources Access Regulator

Dams Safety New South Wales

Declared dams consequence category assessment and determination methodology

for

Dams Safety Act 2015

Contents

Declared dam consequence category assessment and determination

1 Background

The *Dams Safety Regulation 2019* (**Regulation**) requires that:

- an owner of a declared dam must ensure that the consequence category of the dam is assessed by a competent person, and
- the consequence category assessment must be carried out using this methodology.

2 Consequence category assessment

(1) A dam consequence category assessment must be based on either a potential loss of life (PLL) assessment in the manner prescribed by Table 1 of this methodology or a population at risk (PAR) assessment in the manner prescribed by Table 2 of this methodology.

(2) If a consequence category assessment based on PLL is different from a consequence category assessment based on PAR for a dam, the consequence category assessment based on PLL must be used to determine the consequence category.

(3) The assessment of consequence category must include, but not be limited to:

(a) identification of the scenarios which represent the potential for dam failure,

(b) an estimate of the downstream inundation characteristics for these scenarios,

(c) an estimate of the potential loss of life (PLL) and estimate of the population at risk (PAR) for these scenarios, with the weighted mean used for the purpose of assigning the consequence category,

(d) an estimate of the severity of the " damage and loss" grouped as required by section 5 of this methodology for these scenarios, including infrastructure (section 6 Table 3A), environmental (section 7 Table 3B), and health and social (section 8 Table 3C) considerations, and

(e) an uncertainty and sensitivity analysis for the scenarios.

(4) In the identification and analysis of the scenarios in (3) above, two types of dam failure must be considered:

(a) failures that occur without any attendant natural flooding, giving rise to the 'Sunny Day' Consequence Category (SDCC), and

(b) failures that occur in association with a natural flood, giving rise to the Flood Consequence Category (FCC). The FCC should be based on the incremental consequence over natural flood and be limited to above a 300mm increment.

(5) The higher of the SDCC and FCC must be used to determine the consequence category of the dam.

Notes

(1) The SDCC is normally used to determine design standards for seismic stability and the FCC is used in order to determine the flood capacity required for a prescribed dam. All other design requirements, (e.g. internal erosion, conduit security etc) usually involve consideration of the dam's SDCC.

(2) Routine inspection and monitoring frequencies are normally based on the SDCC.

3 Consequence category determination based on potential loss of life

For the purposes of 2 (1), the following table (Table 1) must be used to determine a consequence category based on the PLL method.

Table 1

Potential Loss of Life (PLL)	**Severity of Damage and Loss**			
	Minor	**Medium**	**Major**	**Catastrophic**
Less than 0.1	Very Low	Low	Significant	High C
0.1 to less than 1	Significant	Significant	High C	High B
1 to less than 5		High C	High B	High A
5 to less than 50		High A (where PLL is 5 or above and less than 10, can be reduced to High B)	High A	Extreme
50 or more			Extreme	Extreme

4 Consequence category determination based on population at risk

(1) For the purposes of 2 (1), the following table (Table 2) must be used to determine a consequence category based on the PAR method.

Table 2

Population at Risk (PAR)	**Severity of Damage and Loss**			
	Minor	**Medium**	**Major**	**Catastrophic**
Less than 1	Very Low	Low	Significant	High C
1 to 9	Significant or High C, if a potential for one or more lives being lost	Significant or High C, if a potential for one or more lives being lost	High C	High B
10 to 99	High C	High C	High B	High A
100 to 999		High B	High A	Extreme
1,000 or more			Extreme	Extreme

Notes:

(1) It is acknowledged that these tables are based on the Australian National Committee on Large Dams (ANCOLD) Guidelines on the Consequence Categories for Dams (October 2012). In determining the consequence category of a dam, dam owners should follow Australian National Committee on Large Dams (ANCOLD) *Guidelines on the Consequence Categories for Dams (October 2012)* unless otherwise indicated in this methodology.

(2) In calculating the PLL and PAR, account is to be taken of workers on site, itinerant as well as non-itinerant persons.

(3) The following methods may be used as the basis for calculation of the PLL:

(a) The method described in the following publication: Graham, W J, 1999, *A Procedure for Estimating Loss of Life Caused by Dam Failure, DSO-99-06, U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado*. https://www.usbr.gov/ssle/damsafety/TechDev/DSOTechDev/DSO-99-06.pdf When using Graham's method for estimating loss of life, the criterion boundary from low to medium flood severity should be D ≥ 3m and DV ≥ 4.6m2/s. The criterion boundary from medium to high flood severity should be DV ≥ 15m2/s and the maximum rate of rise ≥ 3m per 5 minute period (i.e. too rapidly to allow people a reasonable chance to escape).

(b) United States Bureau of Reclamation (USBR), RCEM – Reclamation Consequence Estimating Methodology (2015): Guidelines for Estimating Life Loss for Dam Safety Risk Analysis.

(c) Developed and already- applied software modelling systems that involve spatially-distributed, dynamic simulations for estimating potential loss of life (PLL) loss from natural and dam failure floods; particularly for very large and high or extreme consequence category dams with an expected large estimated loss of life.

(4) Other methods recommended by ANCOLD may also be used or other alternative methods accepted by a competent person.

5 Consequence category assessment – criteria to be used for estimating severity of damage and loss

(1) For consequence assessment purposes, the potential severity of the damage and losses must be grouped into like consequences related to:

(a) estimated total infrastructure cost,

(b) estimated environmental impacts, and

(c) estimated health and social impacts.

(2) The severity level of each of these potential damages and losses must be determined to be either: minor, medium, major or catastrophic, in accordance with Table 3A, Table 3B and Table 3C.

(3) The highest potential severity of the three consequence groups identified in 5 (1) must be used in Table 1 or Table 2 for the determination of the consequence category of the dam.

6 Consequence category assessment – criteria to be used for estimating total infrastructure costs for purposes of 5 (1)

(1) Total estimated infrastructure costs must be considered for residential and commercial, as well as community infrastructure. Costs associated with replacement or repair to the dam must also be included.

(2) The potential severity of the estimated infrastructure costs must be established in the manner prescribed by the following Table 3A.

Table 3A

Type	Minor	Medium	Major	Catastrophic
Residential, Commercial, Community Infrastructure, Dam replacement or repair cost	<$10M	$10M to $100M	$100M to $1B	>$1B

7 Consequence category assessment – criteria to be used for estimating environmental impacts for the purpose of 5 (1)

The potential severity of the estimated environmental impacts must be established in the manner prescribed by the following Table 3B.

Table 3B

Type	Minor	Medium	Major	Catastrophic
Duration of recovery	<1 year	1 to 5 years	5 to 20 years	>20 years
Waters	Discharge from dambreak would not contaminate waters	Discharge from dambreak would contaminate waters	Discharge from dambreak would significantly contaminate waters	Discharge from dambreak would contaminate waters over a very long period
Ecosystems	Discharge from dambreak is not expected to impact on ecosystems.	Discharge from dambreak would have short term impacts on	Discharge from dambreak would have significant impacts on	Discharge from dambreak would have significant long term or permanent impacts on ecosystems.

	Remediation possible	ecosystems with natural recovery expected.	ecosystems with natural recovery expected to take many years	Remediation unlikely.
Endangered Ecological Communities and Threatened Species	Minimal damage expected. Recovery within one year	Losses expected to be recovered over a number of years	Severe impacts. Recovery will take many years	Permanent loss or damage to endangered ecological communities or threatened species
Material detained by a tailings/ash dam	Benign solid/liquid	Saline liquid/ unsightly solid contents	Acid contents	Highly reactive/toxic contents

8 Consequence category assessment – criteria to be used for estimating health and social impacts for the purpose of 5 (1)

The potential severity of the estimated health and social impacts must be established in the manner prescribed by the following Table 3C.

Table 3C

Type	Minor	Medium	Major	Catastrophic
Human health (eg by contamination of water, lack of water or release of sewage or toxins)	<100 people affected	100 to 1000 people affected	>1000 to 10000 people affected for greater than one month	>10,000 people affected for a year or more
Loss of services to the community (eg water, gas, electricity, communications or transport)	<100 people affected	100 to 1000 people affected	>1000 to 10,000 people affected for greater than one month	>10,000 people affected for a year or more
Emergency services organisations staff or volunteers deployment	<1000 person days	1000 to 10,000 person days	>10,000 to 100,000 person days	>100,000 person days

Dislocation of people	Persons required to move from their homes for a period of <100 person months	Persons required to move from their homes for a period of 100 to 1000 person months	Persons required to move from their homes for a period of >1000 to 10,000 person months	Persons required to move from their homes for a period >10,000 person months
Dislocation of businesses	Businesses cease trading for <20 business months	Businesses cease trading for 20 to 200 business months	Businesses cease trading for 200 to 2000 business months	Businesses cease trading for >2000 business months and numerous business failures
Employment affected	<100 jobs affected	100 to 1000 jobs affected	>1000 to 10,000 jobs affected	>10,000 jobs affected
Loss of heritage	Significant damage to a local heritage item	Destruction of a local heritage item or significant damage to a heritage item registered under the Heritage Act 1977 (NSW)	Destruction of a heritage item registered under the Heritage Act 1977 (NSW)	Destruction of a heritage item registered under the Heritage Act 1977 (NSW) or that is the subject of an interim heritage order under that Act; a place included in the Commonwealth Heritage List within the meaning of the Environment Protection and Biodiversity Conservation Act 1999 of the Commonwealth, or a property inscribed on the World Heritage List within the meaning of that Act
Loss of recreational facility	Recreational area or facility of local significance being lost	Recreational area or facility of State significance being lost	Recreational area or facility of national significance being lost	Recreational area or facility of national and international significance being lost