Dams Safety Committee

DSC3A

June 2010
(Updated November 2015)

CONSEQUENCE CATEGORIES FOR DAMS

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1. INTRODUCTION

The *normal requirements* of the NSW Dams Safety Committee (DSC) are set out in its guidance sheets with its principal guidance sheet, *DSC Background, Functions and Operations - DSC1A*, outlining the DSC's general operations and authority.

The DSC continues to give critical consideration to the consequences of dam failure in determining whether to prescribe dams, and in setting the requirements relating to the safety management of dams in NSW.

Dam owners, and their professional advisers, have full responsibility to determine, and take appropriate dam safety management action relative to, the potential failure consequences of their dams. However, the DSC also has a responsibility to promote best practices in the classification of dam failure consequences by drawing owners' attention to any DSC requirements (see Section 2.2) for the processes and procedures involved, as well as providing guidance and assistance to owners on general issues or findings in this area.

The DSC Consequence Category Goals and Key Requirements (Section 2) at the start of the sheet are a summary - the whole sheet is to be read for a proper understanding of DSC considerations on determination of consequence categories for dams.

2. DSC CONSEQUENCE CATEGORY GOALS & KEY REQUIREMENTS

2.1 DSC Consequence Category Goals

The DSC's primary goal in relation to this sheet is that all NSW dams are appropriately and consistently classified as to their dam failure consequence categories to enable the DSC to determine their need for prescription and the level of safety management they are to receive. Another goal is that this dam failure consequence information may inform the level of safety a dam requires under the risk management approach (see DSC1B and DSC2D) being progressively implemented by NSW prescribed dam owners, in line with a whole of Government approach to public safety in NSW.

2.2 DSC Key Requirements

This section summarises the DSC requirements outlined in this sheet.

4. DEFINITION

The term *hazard category*, formerly used as a rating of dam failure consequences, has been replaced for sometime by the term *consequence category*.

A prescribed dam owner shall undertake regular reviews of a dam's failure consequences (usually as part of Surveillance Report requirements - see DSC2C) and shall inform the DSC promptly of any significant changes, which are determined.

5. TYPES OF CONSEQUENCE CATEGORIES

Two types of dam failure are recognised for the purposes of determining a dam's Consequence Category, as follows:

- failures that occur without any attendant natural flooding, giving rise to the 'Sunny Day' Consequence Category (SDCC)**;** and
- failures that occur in association with a natural flood, giving rise to the Flood Consequence Category (FCC replaces IFHC – *incremental flood hazard category* - in ANCOLD guidelines published before May 2000).

DSC is proposing a two tier system of consequence rating. Where *potential loss of life (PLL)* figures have not yet been estimated, an owner can base a tentative consequence category on PAR as in Table 2 of this sheet. Where PLL figures are available, the consequence category is to be based on PLL as in Table 1 of this sheet. The Table 1 rating has primacy and will override any rating based on Table 2.

6. USES OF CONSEQUENCE CATEGORY

The higher of the SDCC or FCC, is used to determine the need for prescription of, and Surveillance Reporting for, a dam, with SDCC usually used for determination of surveillance frequency.

Under the standards-based approach, 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.

7. PROCEDURES FOR ASSIGNING CONSEQUENCE CATEGORIES

Where the reliable assessment of consequences involves specialist knowledge, the DSC requires that appropriate specialists be employed in the consequence classification.

Consequence categories are classified as one of seven levels as follows:-

Extreme, High A, High B, High C, Significant, Low, Very Low

Under the Table 2 system, because PAR may not always be a good indicator of the potential for loss of life, the DSC requires the assessor to comment on the potential for loss of life (total and incremental) in addition to providing the total and pre-dambreak flood PAR figures.

In determining the PLL and PAR, account is to be taken of itinerant as well as non-itinerant populations (see note 4, Table 2).

The "damages and losses" categories in the ANCOLD guidelines should be treated as advisory only.

The DSC will consider, on a case by case basis, any proposal by a dam owner to reduce the Consequence Category on the basis of the dam having a "thick" profile (i.e. has a wide crest or non-liquefiable contents).

3. BACKGROUND

This guidance sheet supersedes DSC13 and has been prepared to outline and clarify the processes and procedures the DSC considers necessary for classification of the failure consequence categories of NSW dams. In this regard, the DSC has had significant input to, and has adopted with qualifications the publication of the Australian National Committee on Large Dams (ANCOLD) *Guidelines on the Consequence Categories for Dams* (October 2012). Consequently, it is the DSC's policy that dam

owners should comply with these ANCOLD Guidelines unless otherwise indicated in this or other DSC guidance sheets.

DSC3A applies to all dams in NSW. However, on the basis of a dam's consequence categories, determined in accordance with this sheet, the DSC decides whether that dam should be prescribed under the NSW *Dams Safety Act, 1978* and come under the DSC's regulatory oversight. Generally, the DSC prescribes, and sets requirements for, those dams storing water or other liquefiable materials that pose a significant potential threat to the interests of the community (including environmental effects).

4. DEFINITION

The term "hazard" has been used by ANCOLD (and dam owners world-wide through ICOLD - Internal Commission on Large Dams) over several decades to refer to the scale of potential dam failure consequences. However, in risk analysis it is understood to mean "that which has the potential for harm" and for dams it would refer to the threat or event which could cause a dam failure. The term "Consequence Category" has been adopted by ANCOLD and the DSC for the classification of potential impacts resulting from a dam failure.

The DSC assigns "Consequence Categories" to a dam according to the seriousness, and magnitude, of the adverse consequences affecting the community's interests, including environmental effects, which could be expected to result from that dam's failure. In assigning such consequence categories, no account is taken of the likelihood of dam failure. Thus a dam which meets the highest safety standards, and which therefore is extremely unlikely to fail, can have a *HIGH* Consequence Category.

In addition, it should be noted that the consequence categories for a dam can vary with time due to such things as changes in downstream development or modifications to the dam. Therefore, a prescribed dam owner shall undertake regular reviews of a dam's failure consequences (usually as part of Surveillance Report requirements - see DSC2C) and shall inform the DSC promptly of any significant changes, which are determined.

5. TYPES OF CONSEQUENCE CATEGORIES

5.1 The Basic Distinction

Many dams have failed throughout the world, often with disastrous consequences. A small number of large dams have failed, or partially failed, in Australia but only one of those failures involved loss of life (Briesis Dam, Tasmania, 1929).

Natural flooding is the cause of considerable devastation and even loss of life from time to time. However, it has been recognised internationally that dam owners should not be accountable for the consequences of natural flooding which passes through their dam without dam failure (however, see Sub-section 5.4).

Therefore two types of dam failure are recognised for the purposes of determining a dam's Consequence Category, as follows:

- failures that occur without any attendant natural flooding, giving rise to the 'Sunny Day' Consequence Category (SDCC); and
- failures that occur in association with a natural flood, giving rise to the Flood Consequence Category (FCC replaces IFHC – *incremental flood hazard category* - in ANCOLD guidelines published before May 2000).

Note that it is quite possible for a dam to have a *HIGH SDCC* but a *LOW FCC* (e.g. concrete dams that overtop and 'drown out' in floods) or conversely, it is possible for the dam to have a *LOW SDCC* but a *HIGH FCC* (e.g. retarding basins).

5.2 Two Tier Consequence Rating System

ANCOLD has based consequence categories on *population at risk (PAR)* as a worst case proxy for loss of life but the DSC is concerned that this may underestimate the FCC for dams (if incremental PAR is used) or may result in costly safety improvements (especially if the PAR is located a long way downstream of the dam). To deal with this reality, DSC is proposing a two tier system of consequence rating.

Where *potential loss of life (PLL)* figures have not yet been estimated, an owner can base a tentative consequence category on PAR as in Table 2 of this sheet. The term *potential loss of life* in this Guidance Sheet is now consistent with the definition used for PLL in the ANCOLD *Guidelines on the Consequence Categories for Dams* (October 2012). Where PLL figures are available, the consequence category is to be based on PLL as in Table 1 of this sheet. The Table 1 rating has primacy and will override any rating based on Table 2. In particular cases, the DSC may require that consequence categories be classified according to Table 1.

5.3 Sunny Day Consequence Category (SDCC)

The SDCC should, in principle, be based upon the "worst case" consequences resulting from the most unfavourable failure circumstances of a dam, at a time when flows in the stream on which the dam is situated, are "normal" (i.e. non-flood flows). These consequences include potential loss of life, as well as damage to property, services and environmental values that are directly attributable to dam failure.

The cause of dam failure could be such things as slope instability, internal erosion, or due to seismic loading (e.g. sliding or foundation / embankment liquefaction).

5.4 Flood Consequence Category (FCC)

The FCC should, in principle, be based upon the consequences that result from the most unfavourable failure circumstances of a dam during a flood and which are attributable to the failure of the dam.

The consequences to be taken into account would be similar to those for the SDCC case but would include consideration of the dambreak wave front effect on the areas inundated before failure, as well as the additional areas of inundation after failure. For assessment of the FCC it would be important to consider the

qualitative differences between dambreak floods and the natural floods that are routed through the spillway. Dambreak floods can carry large debris and sediment loads, sometimes have steep wave fronts and rise very rapidly. They are typically larger than any natural flood ever experienced over geologic time and consequently they scour soil materials to bedrock in some places and deposit massive sediment fans in other places.

In assessing the FCC, the cause of dam failure would typically be flood related. Examples of such causes are overtopping of an embankment dam or stability failure of a concrete gravity dam due to high flood surcharge levels. However a dam could suffer a piping or other type of failure that may also be associated with sunny day conditions, during a flood. Any potential failure mode during a flood should be considered in assigning the FCC.

Incremental consequences of failure are determined by examining the consequences that would result without dam failure, and the consequences that would result from the same flood event with dam failure, for a range of floods up to the Probable Maximum Flood (PMF). The differences between these two sets of consequences for a particular flood magnitude would be the incremental consequences; that is, those directly attributable to the dam failure, for that flood condition.

It is necessary to undertake sufficient flood magnitude and consequence assessments to be able to reasonably identify the flood magnitude that would produce the most severe incremental consequences. The requirement to compare the *failure* and *no failure* consequences still holds where the dam can safely pass the PMF. The maximum differential impact between the *"with failure"* and *"without failure"* cases, over the full range of possible flood magnitudes, would be the basis for assignment of the FCC on an incremental consequences basis.

With regard to the clearly rational concept of incremental consequences, the assessor should be mindful that, in the aftermath of a dam failure, it might not be a simple matter to distinguish between the consequences directly attributable to the dam failure, and the flooding consequences from the flood event which caused the dam's failure. For this and other reasons, the DSC requires owners to provide estimates of both incremental and total consequences (PLL or PAR) to assist the DSC to make a determination of the FCC for a dam.

Determination of the FCC requires preparation of inundation maps for:

(i) Flooding with the dam intact for a range of floods up to the PMF;
(ii) Flooding from dam failure for the same range of floods.

The number of flood discharge states to be considered for inundation mapping will depend on the required rigour and detail for the purpose in hand, but as a minimum should be two, the estimated flood capacity (see the definition in the last paragraph of this sub-section) of the dam, and the PMF. Where there have not yet being

analyses to estimate the flood capacity, the default position could be the DCF (*Dam Crest Flood* – see ANCOLD *Guidelines on Selection of Acceptable Flood Capacity for Dams*, March 2000).

However, the aim is to strike a balance between two competing needs of:

- limiting the number of breach analyses, dambreak analyses and consequence assessments in view of the high costs involved; and
- reliably identifying the flood condition with the worst incremental consequences.

For example, if an embankment dam would be prone to a piping failure at a flood considerably less than the DCF, the incremental consequences at that lesser flood could be appreciably worse than the incremental consequences at the DCF.

The owner is to demonstrate to the DSC that sufficient analysis has been undertaken to reliably identify the flood case with the worst incremental consequences.

A dam's flood capacity is usually not known as a single flood value but is recognised to be within an estimated range of flood magnitudes. For the DSC's purposes, the flood capacity is to be taken as the maximum flood condition for which the owner's engineer(s) is prepared to certify that the dam is safe.

6. USES OF CONSEQUENCE CATEGORIES

Sunny Day and Flood Consequence Categories are used for three important purposes:

(i) To determine whether a dam should be prescribed under the NSW Dams Safety Act (see DSC1A) – Table 2 or Table 1 system, the latter to take precedence;

(ii) To provide guidance on setting the level and frequency of surveillance and reporting that is appropriate for a prescribed dam (see DSC1A, DSC2A & DSC2C) – Table 2 or Table 1 system, the latter to take precedence;

(iii) To determine the design standards (level of safety and review frequency) that a prescribed dam is to meet under the standards-based approach (see DSC2D, DSC3B & DSC3C) – Table 1 system only.

The higher of the SDCC or FCC, is used to determine the need for prescription of a dam and type of Surveillance Report required. SDCC is usually used for determination of the frequency of a dam's routine surveillance (i.e. inspection and monitoring).

Under the standards - based approach, the SDCC is normally used to determine design standards for seismic stability where failure, if it occurred, would most likely take place at a time of normal stream flow. However critical design loadings may rarely involve a seismic loading combined with a moderate long-duration (months) flood event.

Under the standards - based approach, the FCC is used (sometimes in conjunction with an examination of Base Safety Condition - see DSC3B) in order to determine the flood capacity required for a prescribed dam.

All other design requirements (e.g. internal erosion security, conduit security etc), usually involve consideration of the dam's SDCC.

7. PROCEDURES FOR ASSIGNING CONSEQUENCE CATEGORIES

7.1 Consequence Categories are a function of the Magnitude of Adverse Consequences

Consequence Categories depend on the nature and severity of adverse consequences. Whilst SDCC and FCC are measured differently, the procedure for assigning a consequence category in terms of adverse consequences is identical.

7.2 Degree of Rigour in Assigning Consequence Categories

In some cases the *order of* scale of consequences of dam failure is so obvious that a conclusive assignment of a consequence category can be made by inspection (for example, if the PAR must clearly be in the tens of thousands and is located not far downstream of a large dam).

Usually however, a conclusive assessment would require dambreak analyses (refer ICOLD 1998, *Dam Break Flood Analysis - Review and Recommendations* - Bulletin No.111), preparation of inundation maps, surveys of dwelling floor levels, identification of the numbers, ages and health status of persons at risk and consideration of warning times, escape routes and the like. Similarly the impact of loss of storage on the community, and the environmental effects of dam failure may require detailed assessment.

Where the reliable classification of consequences involves specialist knowledge, the DSC requires that the appropriate specialists be employed in the consequence assessment [examples are environmental scientists, heritage scientists and economists].

Initially, consequence categories may sometimes be conservatively assigned on the basis of judgments made by experienced dam engineers. Such classifications should always be regarded as tentative and subject to revision on the basis of any future assessment(s). These judged classifications cannot be used to decide on required safety levels unless there is no non-itinerant PAR.

7.3 Consequence Categories

Consequence Categories represent a continuum that extends from minimal consequences at the low end to catastrophic consequences for a broad community at the high end. However, for practical purposes, consequence categories are classified as one of seven levels as follows:-

Extreme, High A, High B, High C, Significant, Low, Very Low

7.4 Assignment of Consequence Categories

Procedures for assessing the consequences of dam failure and the classification of the associated consequence category under the Table 2 system using PAR are outlined in the ANCOLD *Guidelines on the Consequence Categories for Dams,*

October 2012. The DSC has adopted these Guidelines, with qualifications as in this sheet, to assist dam owners in providing information for the DSC to make an initial [Table 2] determination on the consequence categories for a dam.

The same procedure will apply under the Table 1 system, except that the estimated incremental PLL will be used instead of the PAR. The DSC will use the Table 1 consequence ratings as a conclusive basis for assignment of consequence categories.

In assessing consequences, the following important aspects should be noted:

- The DSC's charter relates only to protection of the community's interests, including protection of the environment. Consequently, the DSC takes no account of a dam owner's private or business risks in assessing a dam's Consequence Categories.
- According to the purpose at hand, assessors should consider whether they need to take into account existing or future planned developments, downstream of dams, in their estimation of dam failure consequences. For example, in assessing the existing safety status of a dam the usual basis would be existing development. In deciding on the needed level of safety improvement, it would often be appropriate to consider the projected future development. The DSC is to be told whether consequences are based on existing or future developments, and the reasons for the chosen basis.
- For the DSC's purposes, the definition of the *population at risk (PAR)*, as defined in the Glossary of the October 2012 ANCOLD Guidelines, is amended to read: *All those who would be significantly exposed to floodwaters within the natural flood, or dambreak zone, if they took no action to evacuate*. This change allows for the estimation of the PAR for natural flooding (without dam failure).
- Under the Table 2 system, because PAR may not always be a good indicator of the potential for loss of life, the DSC requires the assessor to comment on the potential for loss of life (total and incremental) in addition to providing the total and pre-dambreak flood PAR figures.
- Application of the method of Graham (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) could be used as the basis for PLL figures. Other recognised methods for estimation of PLL could be submitted for the consideration of the DSC.
- Graham (1999) implied D (depth) ≥ 3m "or" DV (depth x velocity) ≥ 4.6 m^2/s as the criteria for the boundary from low to medium flood severity. However, when using Graham's method for estimating loss of life, the criterion boundary from low to medium flood severity shall be D ≥ 3m "and" DV ≥ 4.6m^2/s. Also when using Graham's method, the criterion boundary from medium to high flood severity shall be DV ≥ 15m^2/s "and" the maximum rate of rise ≥ 3m per 5 minute period (i.e. too rapidly to allow people a

reasonable chance to escape). These boundary criteria are based on the following:

  - US Department of Homeland Security (DHS), Dams Sector (2011), *Estimating Loss of Life for Dam Failure Scenarios*, September 2011 – see in particular p. 20.
  - Lang, S., Hill, P. and Graham, W. (2012), *Estimating Potential Loss of Life from Dam Failure in the Digital Age*, Proceedings of ANCOLD Conference, Perth, November 2012.
  - Confirmations from W. Graham in personal communications with several engineering specialists and authors of papers.

- In determining the PLL and PAR, and for assessing the potential for loss of life, account is to be taken of itinerant as well as non-itinerant populations (see note 4, Table 2).
- The Total PAR is the total population occupying the full extent of the dambreak affected zone (including) that area affected by natural flooding prior to dambreak) immediately prior to the onset of flooding. In some circumstances Dambreak PAR may be used, which is based on the Total PAR minus the PAR affected by a natural flood event immediately prior to the dambreak. See the October 2012 ANCOLD Guidelines for the limitations and criteria that need to be met for use of Dambreak PAR.
- The "damages and losses" categories in the ANCOLD Guidelines should be treated as advisory only and more detailed assessments may be required in particular circumstances, particularly for environmental consequences (see Sub-section 7.5). This might apply in relation to dams in sensitive natural environmental areas, where no, or limited, PAR exist. In addition, the DSC gives particular guidance on the consequence assessment of tailings dams in its guidance sheet on *Tailings Dams (DSC3F).* Where a dam stores something other than clean water reference should be made to that document.
- To reflect the DSC's requirements, Table 3 of the ANCOLD Guidelines forms the basis for the following Table 2 in this Guidance Sheet. The latter has some additional notes.
- The DSC will consider, on a case by case basis, any proposal by a dam owner to reduce the Consequence Category on the basis of the dam having a "thick" profile (i.e. has a wide crest or non-liquefiable contents). The owner will be expected however to develop this case with full consideration of the geometry, dam materials, nature of stored substances, phreatic surface, storage volume of the dam and estimated peak outflow discharge.

TABLE 1

CONSEQUENCE CATEGORIES BASED ON POTENTIAL LOSS OF LIFE [PLL]

Based on the ANCOLD *Guidelines on the Consequence Categories for Dams*, Table 4.

Potential Loss of Life (PLL) ***(Note 4)***	**Severity of Damage and Loss**			
	Minor	**Medium**	**Major**	**Catastrophic** ***(Note 3)***
<0.1	Very Low	Low	Significant	High C
≥0.1 to <1	Significant	Significant	High C	High B
≥1 to <5	*(Note 1)*	High C	High B	High A
≥5 to <50		High A *(Note 4)*	High A	Extreme
≥50		*(Note 1)*	Extreme	Extreme

Note 1: With a PLL of more than 1 it is unlikely that the severity of damage and loss will be "Minor".

Similar with a PLL greater than 50 it is unlikely damages will be classified as Medium".

Note 2: The PLL is to be estimated by the methods of Graham, WJ, 1999, A Procedure for Estimating Loss of Life Caused by Dam Failure, DSO-99-06, US Department of the Interior, Bureau of Reclamation, Denver, Colorado or another recognised method approved by the DSC. When using Graham's method, adopt the criteria between the various flood severity boundaries as noted in Section 7.4 of this Guidance Sheet. Because of the computational methods followed in estimating PLL, it is possible to have a notional PLL, which is less than 1.0 or a PLL greater than 1.0 which is not an integer. Given a particular dam failure scenario (which has its own probability), a PLL less than 1.0 is to be interpreted as the probability of the loss of one life. Thus a PLL of 0.1 would be interpreted as a probability of 1 in 10 that a life would be lost, given the failure scenario. A PLL greater than 1.0 should be rounded to the nearest integer.

Note 3: Catastrophic Damages is a new category at the upper end of Major Damages defined in the ANCOLD Guidelines.

Note 4: Where PLL is in the range ≥5 to <10, and the Severity of Damage and Loss is Medium, the Consequence Category level can be reduced to High B.

TABLE 2

CONSEQUENCE CATEGORIES BASED ON POPULATION AT RISK [PAR]

Based on the ANCOLD *Guidelines on the Consequence Categories for Dams,* Table 3.

Population at Risk (PAR) *(Note 4)*	**Severity of Damage and Loss**			
	Minor	**Medium**	**Major**	**Catastrophic** (Note 5)
<1	Very Low	Low	Significant	High C
≥1 to <10	Significant *(Note 2)*	Significant *(Note 2)*	High C	High B
≥10 to <100	High C *(Note 3)*	High C	High B	High A
≥100 to <1,000	*(Note 1)*	High B	High A	Extreme
≥1,000		*(Note 1)*	Extreme	Extreme

Note 1: With a PAR in excess of 100, it is unlikely that the severity of damage and loss will be "Minor". Similarly with a PAR in excess of 1,000 it is unlikely Damages will be classified as "Medium".

Note 2: Change to "High C" where there is the potential of one or more lives being lost.

Note 3: Refer to Sections 1.6, 2.8 and Tables 3 & 4 of the ANCOLD *Guidelines on the Consequence Categories for Dams*, October 2012 for explanation of the range of Consequence Categories.

Note 4: The contribution to PAR of non-itinerants (i.e. regular occupants of dwellings, schools, hospitals, commercial and industrial premises and other permanent places of occupation) shall be the largest total population that is exposed at the one time on a regular basis. To allow for the variable exposure of itinerants, the contribution to PAR of such populations shall be computed on the basis of exposure factors. Where low exposure factors are applied to few itinerants, it is possible to have a notional PAR, which is less than 1.0.

Note 5: Catastrophic Damages is a new category at the upper end of Major Damages defined in the ANCOLD Guidelines.

7.5 DSC Additions to ANCOLD's Consequence Assessment Criteria for Health and Social Impacts and Environmental Impacts

The DSC had previously developed and trialled a consistent and robust approach for consideration of the cultural heritage issues (part of health and social impacts) and environmental impacts for consequence assessment criteria. It believes the approaches to be user-friendly and helpful as quantitative assessments.

The following tables in Appendix A are offered as DSC guidance, particularly Table B3 Health and Social Impacts (specifically the loss of cultural heritage issue) and Table B4 Environmental Impacts. Both of these tables match in number and title with the respective tables in Appendix B of the ANCOLD Guidelines on the Consequence Categories for Dams, October 2012. In addition, the "Health and Social impacts" and "Environmental impacts" sections of Table 2: Severity of Damages and Losses of the October 2012 ANCOLD Guidelines (which is not attached) should be amended to account for the additional issues as outlined in Appendix A of this DSC Guidance Sheet.

APPENDIX A

DSC ADDITIONS TO ANCOLD *GUIDELINES ON THE CONSEQUENCE CATEGORIES FOR DAMS* (OCTOBER 2012) APPENDIX B

DATA ASSEMBLY AT LEVELS OF ASSESSMENT

Type of Data	Assessment Level		
	Initial	**Intermediate**	**Comprehensive**
Environmental	General information from topographic and ortho-photo maps[1].	• General information from topographic and ortho-photo maps[1]. • Reviews of government data-bases[2].	• Professional advice. • Professional surveys[3]. • Formal environmental impact assessment[4].

Explanatory notes for environmental data

1	Topographic and ortho-photo maps provide good information on environmentally sensitive areas including: • Areas of native vegetation • Historic Sites • Landform features that may have natural heritage values. • National Parks • Wetlands
2	Government Departments maintain databases on endangered species and heritage items.
3	Surveys of vegetation, animals (including aquatic species), indigenous and non-indigenous heritage items.
4	Formalised impact assessment should follow established state or national processes, such as the NSW Government's "IS and EIS required?" Best Practice Guidelines for Part 5 of the Environmental Planning and Assessment Act 1979. An alternative is to carry out a qualitative risk assessment on environmental impacts.

✪ Selection of the severity of damage and loss

B 3 HEALTH AND SOCIAL IMPACTS

Type	Minor	Medium	Major	Catastrophic
Loss of cultural heritage[1].	No expected physical damage to heritage items.	Significant physical damage to item(s) of local heritage[2].	Significant physical damage to item(s) of state heritage[3].	Significant physical damage to item(s) of National or World heritage[4].

Explanatory notes

Loss of Cultural Heritage	1. Cultural heritage include items of value to indigenous or non-indigenous communities, such as historic and archaeological sites, places and buildings that may be damaged or destroyed. When assessing cultural heritage, consideration should be given to the business risks and liabilities for which the organisation may be held responsible.
	2. Information available on local environmental plans available from local government.
	3. Information available from State government heritage databases (e.g. NSW State Heritage Register on www.heritage.nsw.gov.au and the Aboriginal Sites Register).
	4. Information available from the Federal Government via www.environment.gov.au, which provides the National Heritage List and a list of World Heritage sites within Australia.

✪ Selection of the severity of damage and loss

B 4 ENVIRONMENTAL IMPACTS

Where a dam stores something other than clean water reference should also be made to Guidance Sheet DSC3F Tailings Dams.

Type	Minor	Medium	Major	Catastrophic
Area of impact[1]	< 1 km^2	< 5 km^2	< 20 km^2	> 20 km^2
Duration of impact[2]	< 1 year	< 5 years	< 20 years	> 20 years
Impacts on conservation value	Physical damage limited to areas that are extensively cleared of vegetation[3].	Limited physical damage to: A. item(s) of local[4] and state natural heritage[5] B. native vegetation within state recognised forestry, aquatic and conservation reserves[5], or recognised habitat corridors, wetlands or fish breeding areas[5].	Significant physical damage to areas A & B. Limited physical damage to: C. item(s) of National or World natural heritage[5]. D. native vegetation within national parks[5], recognised wilderness areas[3], RAMSAR wetlands[6] and nationally protected aquatic reserves[6].	Extensive damage to areas A & B. Significant physical damage to areas C & D.
Impacts on plants and animal habitat	Impact in extensively cleared or disturbed areas[7].	Loss of habitat for protected native species[5].	Significant loss of habitat for regionally or state-listed rare or endangered species[5].	Significant loss of habitat for national rare or endangered species[6].
Riverine landscape processes	No changes expected to river channel post inundation.	Localised impacts in river connectivity expected.	Some cutoffs expected.	Significant change in river course expected.

Explanatory notes

1	Land inundated by dam failure, exclusive of land that is prone to inundation by natural flooding.
2	The removal of topsoil from flood plains and erosion of waterways may cause a long term scar. Habitats may take a long time to recover as areas of debris and gravel may prevent regrowth.
3	Information available from topographic maps.
4	Information available on local environmental plans available from local government.
5	Information available from state government departments on natural heritage, conservation reserves, endangered species, etc.
6	Information available from the Federal Government via www.environment.gov.au, with information on nationally protected natural heritage, World Heritage sites within Australia, nationally and internationally protected endangered species etc.
7	It is acknowledged that agricultural use is not an empirical measure of soil fertility.

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