BHP

ESG briefing: Tailings dams

June 2019

Escondida

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Key messages

Introduction to tailings dams	**There are three broad design types for tailings dams: upstream, downstream and centerline** • Environmental conditions and the nature of tailings need to be considered when designing mine tailing storage. • Dam consequence or classification ratings are based on the modelled, hypothetical most significant failure mode without controls – not on the current physical stability of the dam. They inform dam design, surveillance and reviews.
Tailings Facilities in the portfolio	**We have 67 operated tailings facilities[1] across all sites** • 13 operated facilities are active, 12 of which are in Australia and 1 in Chile. 29 of our operated facilities are upstream, 5 of which are active. • At our non-operated joint ventures there are 9 facilities, 5 of which are upstream, of which all are inactive. • The Dam Risk Review identified no immediate concerns regarding dam integrity. Subsequently we have undertaken Dam Safety Reviews which provide assurance statements on dam integrity.
Approach to dam risk management at BHP	**Maintaining dam integrity requires ongoing focus on appropriate engineering design, quality construction, operating discipline and effective governance. This is enabled through:** • Maintenance of dam integrity; • Governance of dam facilities; • Monitoring, surveillance and review; and • Emergency preparedness and response.
The Future	**BHP is committed to supporting the development of an international standard and independent monitor for tailings facilities globally** • We are establishing a dedicated Tailings Task Force to drive enhanced focus on internal dam management plus support the development of international best practice. • We are progressing the investigation of new technologies to further mitigate current dam risks and eliminate future risk. • We continue to work with the ICMM and our peers to drive a step change in tailings management across the sector.

1. The number of tailings facilities is calculated based on the definition agreed by the International Council on Mining and Metals Tailings Advisory Group in response to the Church of England information request which differs to the definition applied to our February disclosure. We keep this definition under review. The reduction in number of facilities in this disclosure compared to the February disclosure is primarily due to the aggregation of individual dams into (integrated) facilities. The majority of these changes are associated with the North American Closed Sites.

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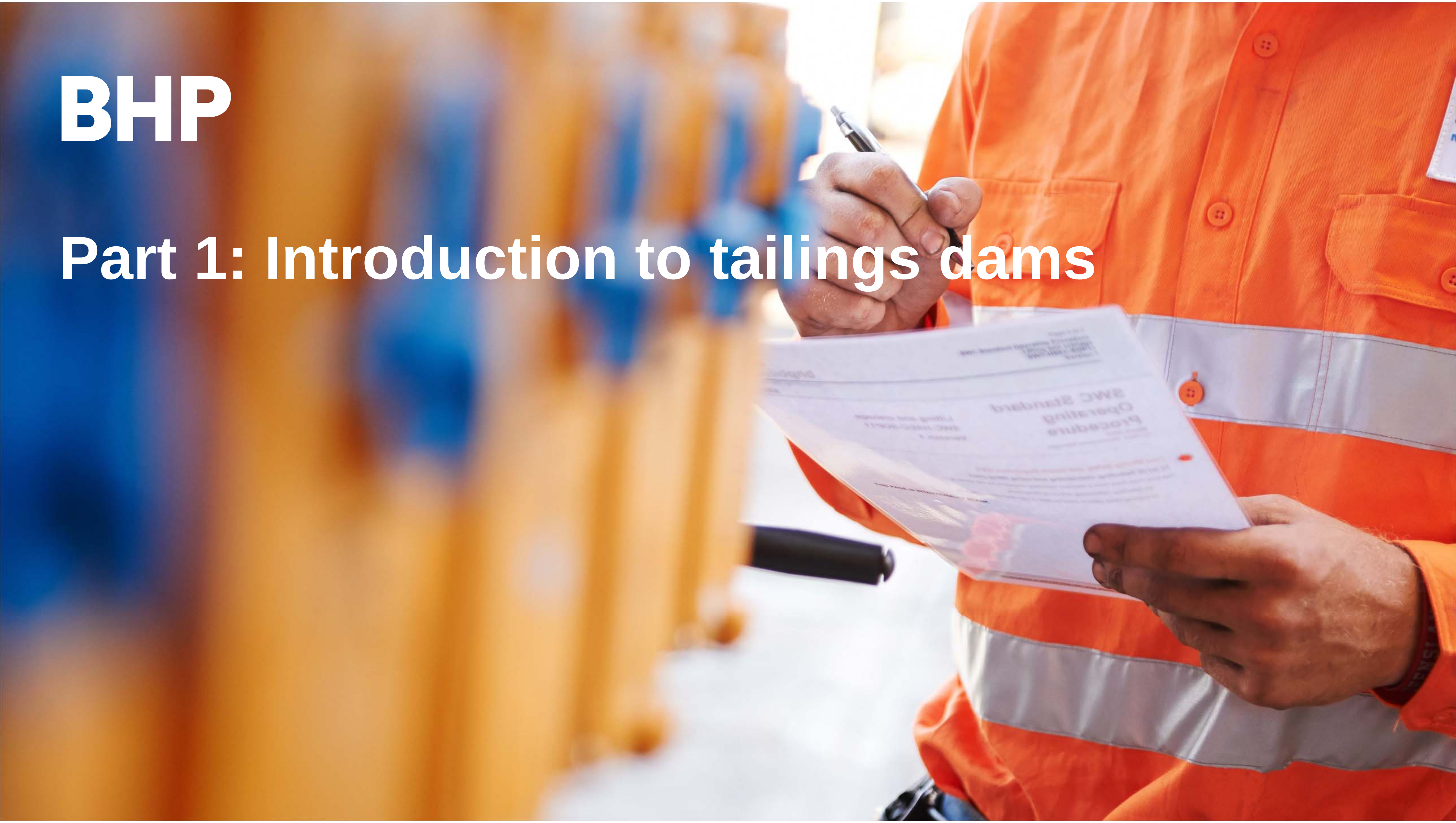
Part 1: Introduction to tailings dams



What are tailings dams?

- A dam is a barrier constructed for the retention of water, water containing any other substance, fluid waste, or tailings[1].
- Tailings dams are designed and operated differently to conventional dams.
- A tailings storage facility, is not yet a formally defined term. Generally it refers to one or more co-located tailings dams[2].

	Tailings	Conventional
Purpose	Contains unrecovered solids, chemicals, and process water, normally as a slurry.	Hydroelectric dams Water reservoirs
Contents	Solids and liquid	Water
Design	Dynamic; the structures are intended to grow over time to accommodate increased tailings over the life of mine. Structures often stand in perpetuity.	Static; once they fill the structures are typically not expanded. At end of life structures can be decommissioned and removed.
Construction	Earth[3], rock	Rock, concrete

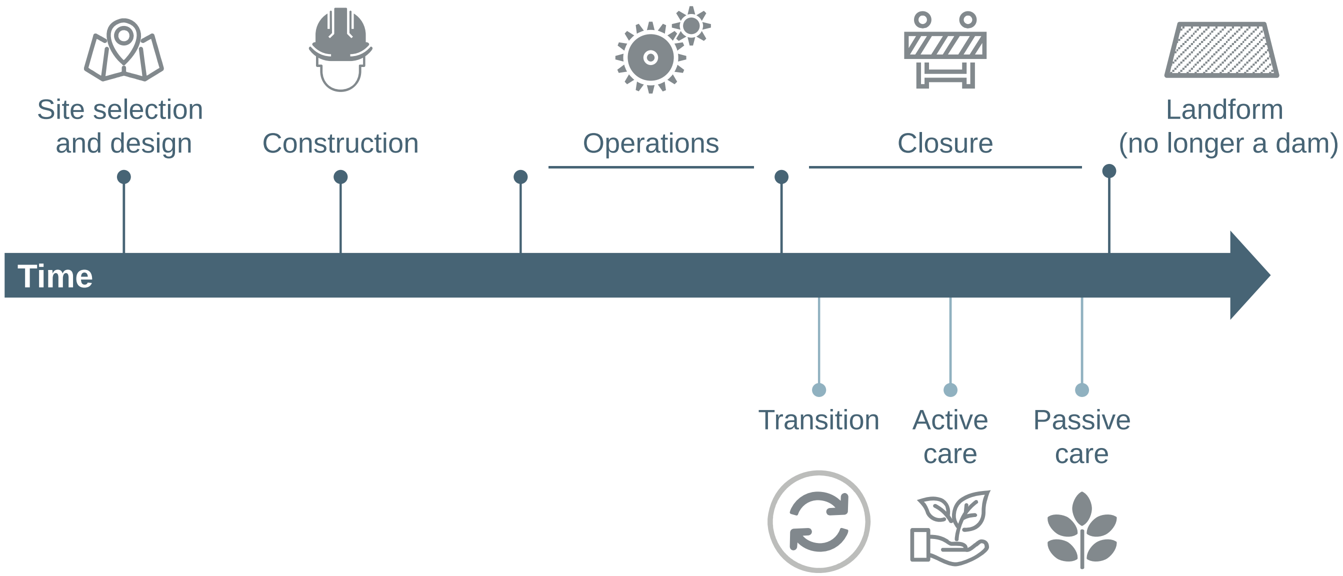
1. Canadian Dam Association Dam Safety Guidelines 2007 (2013 Edition).
2. For the purposes of the Church of England disclosure, a tailings storage facility has been defined by the International Council on Mining and Metals Tailings Advisory Group as an operationally integrated facility of dams/walls. This definition is applied throughout this presentation.
3. Includes cyclone sands.

Escondida Tailings Storage Facility, Chile

Hoover dam, US
(a hydro / water reservoir dam)

Life cycle of tailings dams

Design, construction and operation of tailings dams need to account for possible changes over their long life cycle

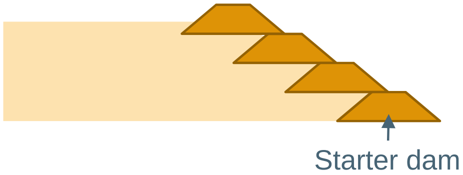
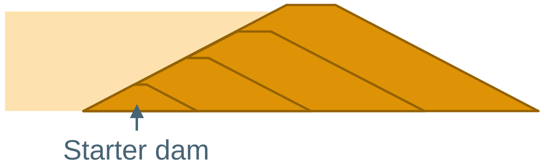
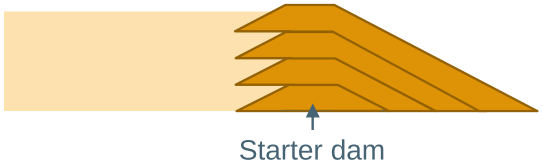


- The operational phase of a dam is dynamic and is likely to include expansion of the dam, raising of the dam height and/or addition of dams.
- The closure phase of a dam can often exceed the operational phase of the dam. It may include transition from operations to active care such as ongoing water, geochemical and physical management to maintain integrity.
- Over time, inactive tailings facilities may transition to passive care where the ongoing water, geochemical, and physical management requirements are reduced or eliminated.

Principal design methods

There are a range of options for tailings dams design, determined in consideration of a range of factors

There are 3 broad types of tailings dam. The selection of design is based on a number of factors including dam siting, geology, seismicity, climatic conditions, construction materials and the nature of tailings. There are also combinations of the three embankment construction types.

	Upstream construction	Downstream construction	Centreline construction
			
Management	Construction relies on the integrity of the tailings for stability. As such, while this construction method has been successfully used for decades, these designs require greater ongoing scrutiny (e.g. longer tailings beaches / small ponds, ongoing verification of the foundation conditions).	This construction method does not rely on the stability of the tailings and therefore can be more versatile during operation (e.g. increased rates of rise, more accommodating of changes in tailings properties).	This construction method is useful where the overall footprint of the dam may have physical constraints.

Factors that influence tailings dam integrity

Maintaining dam integrity requires ongoing focus on appropriate engineering design, quality construction, operating discipline and effective governance

Factors that influence dam integrity include:

- Appropriate consideration of site conditions such as seismicity, climatology, geology, hydrology, and tailings characteristics.
- The quality assurance and quality control of dam construction including materials used for construction and methods of construction.
- Ongoing dam operating discipline, including:
  - tailings characterisation and deposition;
  - effective water management;
  - effective monitoring;
  - appropriate consideration of changes (including ore, operating context, climate, etc).

Elliot Lake Closed Site Tailings Storage Facility
Ontario, Canada

Tailings dam classification systems

Tailings dam classification informs design and management of dam facilities and assessment of dam risk

- BHP primarily classifies dams according to both the classification system of the Canadian Dam Association (CDA) and the Australian National Committee on Large Dams (ANCOLD).
- Dams are classified to inform:
  - design criteria;
  - surveillance programs;
  - dam safety review frequency and requirements.
- **Dam classification or consequence is generally based on the modelled impacts following a dam break study, of the hypothetical most significant failure mode for the dam, regardless of the probability of failure or the controls in place to manage the risk of failure.**
- Classification is typically assigned by the external Engineer of Record.
- Dam classification informs BHP's approach to risk assessment and management of tailings dams.

Olympic Dam

Tailings dam classification systems

Consequence is based on the most significant, possible outcome in any of the categories, regardless of probability

Classification is based on the modelled, hypothetical most significant failure mode without controls – not on the current physical stability of the dam.

CDA consequence category	Potential loss of life	Environmental and cultural values	Infrastructure and economics
EXTREME	More than 100	Major loss… Restoration impossible…	Extreme losses…
VERY HIGH	100 or fewer	Significant loss… Restoration impractical…	Very high economic losses…
HIGH	10 or fewer	Significant loss… Restoration probable…	High economic losses…
SIGNIFICANT	Unspecified	No significant loss…	Loss to recreational facilities…
LOW	0	No long term loss…	Low economic loss…

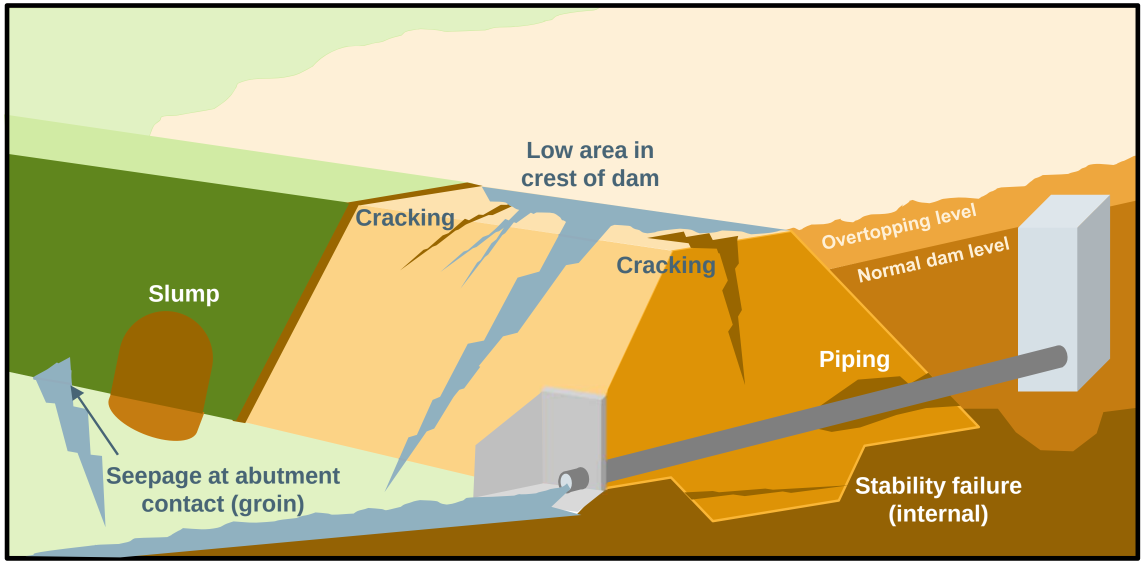
Source: Canadian Dam Association Dam Safety Guidelines 2007 (2013 Edition) and Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2014). The table is an extract of the CDA Dam consequence categories and criteria.

Common terms used to describe failure mechanisms

There are a range of terms used to describe causes for dam failures. Typically, there is not one cause alone that contributes to a failure

- **Overtopping** caused by water volumes that exceed the capacity of the dam.
- **Structural failure** of materials used in dam construction (including from liquefaction, seismicity).
- **Foundation failure** due to movement and/or failure of the foundation supporting the dam.
- **Surface erosion** of the embankment from settlement, cracking.
- **Internal erosion** of the embankment sometimes referred to as piping erosion.
- **Deficiencies in the choice or application of design criteria** (e.g. not appropriate for the setting; construction does not meet engineering requirements).

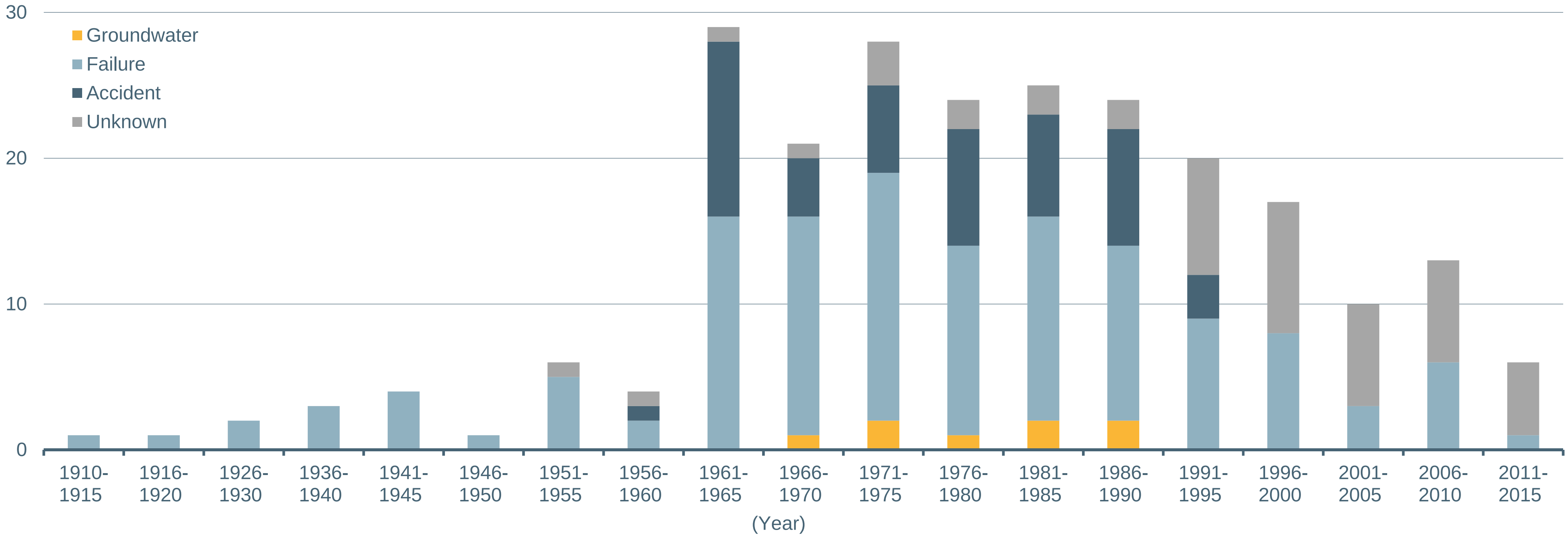
Examples of integrity issues and associated indicators



Industry-wide statistics of tailings dam failures

This study represents one of the most recent analyses of dam failure trends

Tailings dam failures[1, 2]
(Number of records)



1. Ref: The role of water management in tailings dam incidents: Clint Strachan; Stephen Goodwin: *Proceedings Tailings and Mine Waste 2015.* The statistics presented include the dam failure at Mt Polley but not Samarco.
2. The terms used in the study are intended be consistent with other key publications including ones compiled by the International Commission on Large Dams (ICOLD). Failures (indicates a breach of the dam and loss of process water or tailings), accidents (indicates repairs made to the dam with no loss of process water or tailings), and groundwater issues (indicates seepage or groundwater impact issues that were inconsistent with design intent). Unknown indicates that the cause of the incident was not known by the authors of the study.

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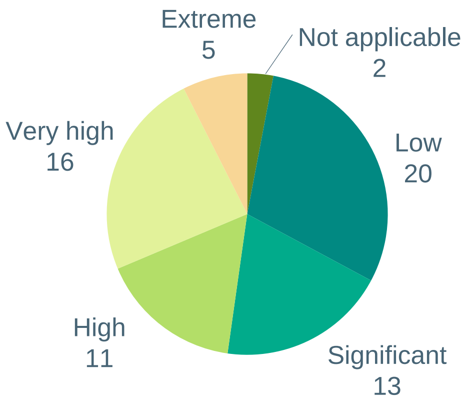
Part 2: Tailings facilities in the portfolio and BHP's dam risk review

Operated tailings facilities in the portfolio[1]

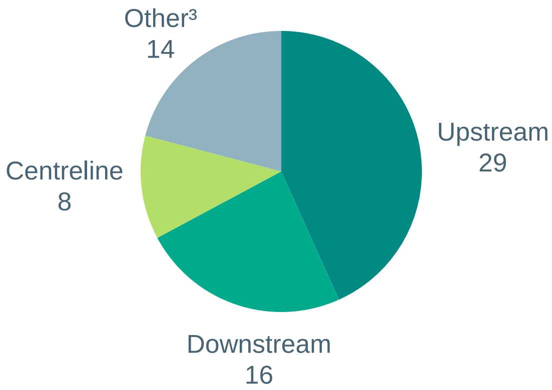
Within the tailings facilities portfolio there are 67 operated tailings facilities

Classification is based on the modelled, hypothetical most significant failure mode without controls – not on the current physical stability of the dam.

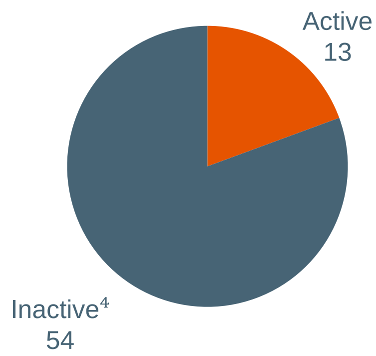
CDA[2] classification of operated tailings facilities



Types of operated tailings facilities



Operational status of operated tailings facilities



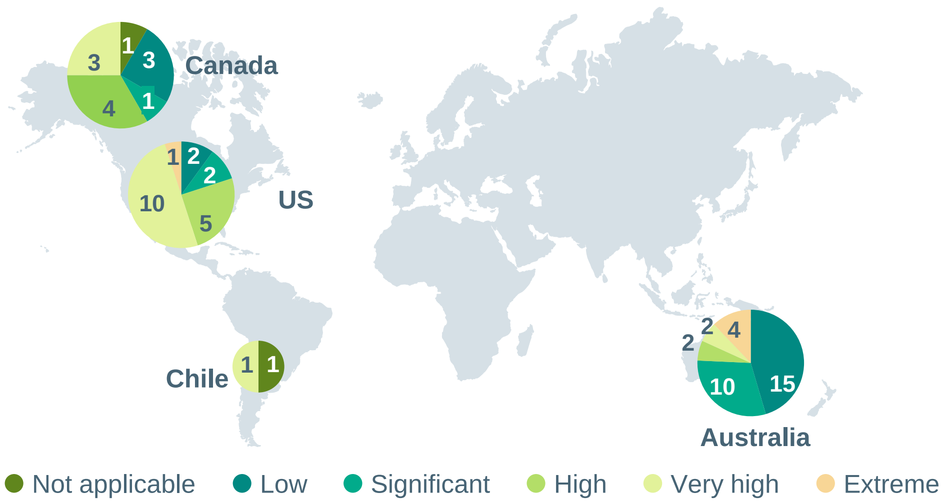
For further details on tailings facilities within the portfolio please see our more detailed disclosure on our website at bhp.com

1. Includes facilities within BHP operations and excludes Non-operated Joint Ventures. The number of tailings storage facilities is calculated based on the definition agreed by the International Council on Mining and Metals Tailings Advisory Group in response to the Church of England information request which differs to the definition applied to our February disclosure. We keep this definition under review. The reduction in number of facilities in this disclosure compared to the February disclosure is primarily due to the aggregation of individual dams into (integrated) facilities. The majority of these changes are associated with the North American Closed Sites. The classification of the tailings facilities is based on the most recent classification of the facilities by the Engineer of Record. This is subject to change as ongoing reviews are conducted.
2. For the purposes of this chart, ANCOLD and other classifications have been converted to their CDA equivalent. Two tailings facilities are not considered dams and therefore not subject to classification (labelled Not applicable): Hamburgo TSF at Escondida is an inactive facility where tailings were deposited into a natural depression; and Island Copper TSF in Canada, acquired in the 1980s, also an inactive facility. Tailings at Island Copper were deposited in the ocean under an approved license and environmental impact assessment. This historic practice ceased in the 1990s. BHP has since committed to not dispose of mine waste rock or tailings in river or marine environments.
3. Includes dams of combined design and the two non-dam tailings facilities of Hamburgo TSF in Chile and Island Copper TSF in Canada.
4. Inactive includes facilities not in operational use, under reclamation, reclaimed, closed and/or in post-closure care and maintenance.

Operated tailings facilities in the portfolio[1]

Classification is based on the modelled, hypothetical most significant failure mode without controls – not on the current physical stability of the dam.

Location and CDA Classification of operated tailings facilities[2]



Location and operational status of operated tailings facilities

For further details on tailings facilities within the portfolio please see our more detailed disclosure on our website at bhp.com

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3. Inactive includes facilities not in operational use, under reclamation, reclaimed, closed and/or in post-closure care and maintenance.

Non-operated JV tailings facilities in the portfolio[1]

Within the tailings facilities portfolio there are 9 non-operated tailings facilities

Classification is based on the modelled, hypothetical most significant failure mode without controls – not on the current physical stability of the dam.

Location and CDA Classification of non-operated facilities[2]

Location and operational status of non-operated facilities

For further details on tailings facilities within the portfolio please see our more detailed disclosure on our website at bhp.com

1. Includes facilities within Non-operated Joint Ventures. The number of tailings storage facilities is calculated based on the definition agreed by the International Council on Mining and Metals Tailings Advisory Group in response to the Church of England information request which differs to the definition applied to our February disclosure. This definition is kept under review. The classification of the tailings facilities is based on the most recent classification of the facilities provided by the operator.
2. The operator is responsible for determining classification in accordance with its internal policies and local guidelines. For the purposes of this chart, the operator's classifications have been converted to their CDA equivalent. This is subject to change as ongoing reviews are conducted by the operator.
3. Inactive includes facilities not in operational use, under reclamation, reclaimed, closed and/or in post-closure care and maintenance.

Tailings facilities with extreme or very high classifications

Classification is based on the modelled, hypothetical most significant failure mode without controls – not on the current physical stability of the dam.

Asset	Location	Primary Dam Type[1]	CDA Consequence Classification[2]	Facility Status[1]	Principal Potential Impact Driver of Dam Classification
Operated Assets					
BMA – Goonyella Riverside	Queensland, Australia	Upstream	Very High	Active (1 TSF)	Employee impacts
Escondida	Region II, Chile	Downstream	Very High	Active (1 TSF)	Employee impacts
Nickel West – Leinster	West Australia, Australia	Upstream	Very High	Active (1 TSF)	Employee impacts
North American Closed Sites – Copper Cities	Arizona, US	Upstream	Very High	Inactive (2 TSFs)	Community impacts
North American Closed Sites – Elliot Lake	Ontario, Canada	Downstream / Centreline	Very High	Inactive (3 TSFs)	Environmental impacts
North American Closed Sites – Miami Unit	Arizona, US	Upstream	Extreme Very High	Inactive (1 TSF) Inactive (1 TSF)	Community impacts
North American Closed Sites – Old Dominion	Arizona, US	Upstream	Very High	Inactive (1 TSF)	Community impacts
North American Closed Sites – San Manuel	Arizona, US	Upstream	Very High	Inactive (5 TSFs)	Environmental impacts
North American Closed Sites - Solitude	Arizona, US	Upstream	Very High	Inactive (1 TSF)	Community impacts
Olympic Dam	South Australia, Australia	Upstream Upstream	Extreme Extreme	Active (2 TSFs) Inactive (1 TSF)	Employee impacts
West Australian Iron Ore – Whaleback	West Australia, Australia	Upstream	Extreme	Active (1 TSF)	Employee impacts
Non-Operated Joint Ventures					
Antamina	Ancash, Peru	Downstream / Centreline	Extreme	Active (1 TSF)	Community impacts
Samarco – Germano	Mariana, Brazil	Upstream	Extreme	Inactive[3] (2 TSFs)	Community impacts

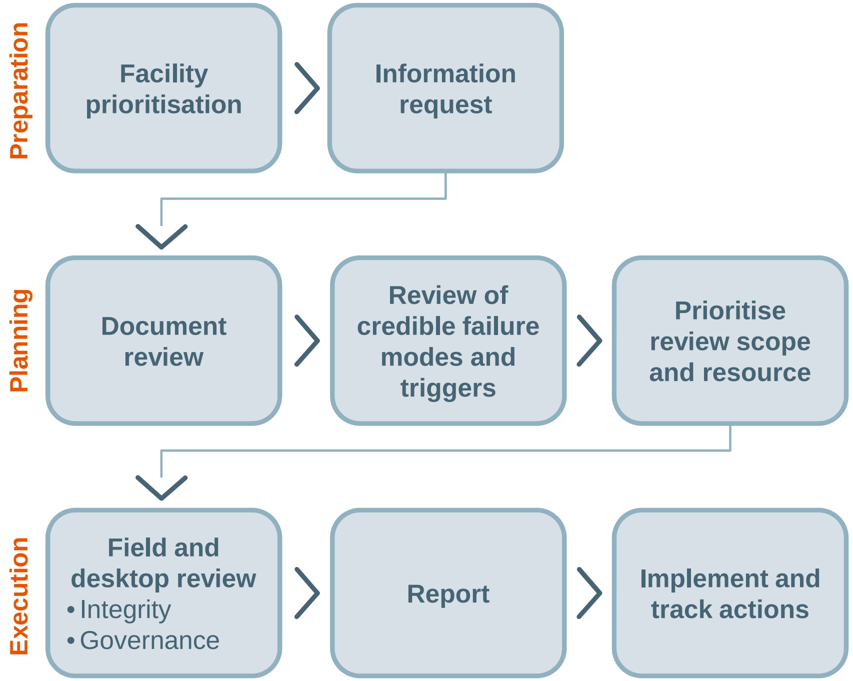
For further details on tailings facilities within the portfolio please see our more detailed disclosure on our website at bhp.com

1. Primary dam type is that associated with the modelled, hypothetical most significant failure mode for the Tailings Storage Facility (TSF). Where a TSF is based on the definition agreed by the International Council on Mining and Metals Tailings Advisory Group.
2. For the purposes here, ANCOLD and other classifications have been converted to their CDA equivalent. The consequence classification stated is that associated with the modelled, hypothetical most significant failure mode for the facility. For Non-Operated Joint Ventures, the operator is responsible for determining classification in accordance with its internal policies and local guidelines. For the purposes here, the operator's classifications have been converted to their CDA equivalent.
3. Germano is in the process of decommissioning.

BHP Dam Risk Review – 2016

The Dam Risk Review was undertaken to assess the management of tailings facilities following the failure of the Fundão dam at Samarco

- The Review assessed dam design, construction, operations, emergency response and governance to determine the current level of risk and the adequacy and effectiveness of controls.
- The scope of the review included:
  - significant[1] tailings facilities across both BHP operated and non-operated assets;
  - any proposed significant tailings or water dams as part of major capital projects; and
  - consideration of health, safety, environment, community and financial impacts associated with failure, including the physical impacts of climate change.
- Undertaken by multi-disciplinary expert teams, combining leading external tailings engineering firms and BHP personnel.
- Actions were assigned at the asset-level to address findings, and followed up by our internal audit teams to assess quality and completeness.
- Actions at the Group-level were identified to address common findings and lessons learned.



1. Significance was determined as part of the review process taking account of the dam classification under CDA and/or ANCOLD. It included active and inactive facilities.

BHP Dam Risk Review

Dam integrity review findings

- The Review identified no immediate concerns regarding dam integrity.
- Tailings dams are however dynamic structures and maintaining dam integrity requires ongoing focus on appropriate engineering design, quality construction, operating discipline and effective governance processes to ensure risk controls are effectively implemented and maintained.
- Subsequently we have undertaken Dam Safety Reviews which provide assurance statements on dam integrity.

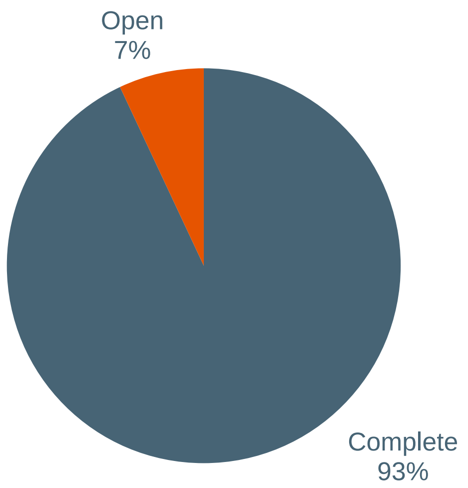
Goonyella Tailings Storage Facility, BMA Queensland Australia

BHP Dam Risk Review
Asset level actions

At the Asset level, the following actions have been taken:

- **Design:** Revise dam break analyses to take account of all credible failure modes and failure paths incorporating liquid and solid flows. Revise design criteria associated with these where required.
- **Emergency Preparedness and Response:** Revise Emergency Response Plans, train personnel and undertake emergency response scenario exercises. Incorporate lessons learned from this back into plans.
- **Roles and Responsibilities:** Assign single point accountability for dam ownership coupled with appointment of a Responsible Dam Engineer for overall dam stewardship and a qualified consultant to be the Engineer of Record, responsible for dam design.
- **Risk Management:** Undertake detailed engineering risk assessments including revisions of risk ratings.
- **Change Management:** Review change management processes to better capture changes for process, plant and personnel related to dams.
- **Review:** Complete Dam Safety Reviews, aligned to the guidance from the Canadian Dam Association – considered the most rigorous in the industry.

>400 Dam Risk Review actions assigned to BHP assets



- 93% of assigned actions have been identified as complete by our assets.
- The remaining open actions in progress are those with longer lead times.
- Our Internal Audit and Assurance function have also been reviewing these actions.

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BHP Dam Risk Review

Group level actions[1]

At the Group level, the following actions have been taken:

- **Accountability:** The Resource Engineering Centre of Excellence has been allocated global accountability for the technical oversight of dam integrity and governance.
- **Standards:** To complement existing risk management requirements, a common standard for the management of dam risk has been developed so that there are clear, minimum requirements for dam integrity and governance including design, operations, construction, review and emergency response.
- **Review:** Dam Safety Reviews are being undertaken across BHP and a process for independent review boards is being established across the company.
- **Technology:** The assessment of technology options to further reduce dam integrity risk is progressing in conjunction with Group Technology.
- **Industry collaboration:** BHP has continued to support industry-wide efforts to improvement the management and reduce risk of tailings facilities, including the development of the ICMM Position Statement.

1. Group-level actions are those that apply at a global, company-wide level for all BHP operated Assets.

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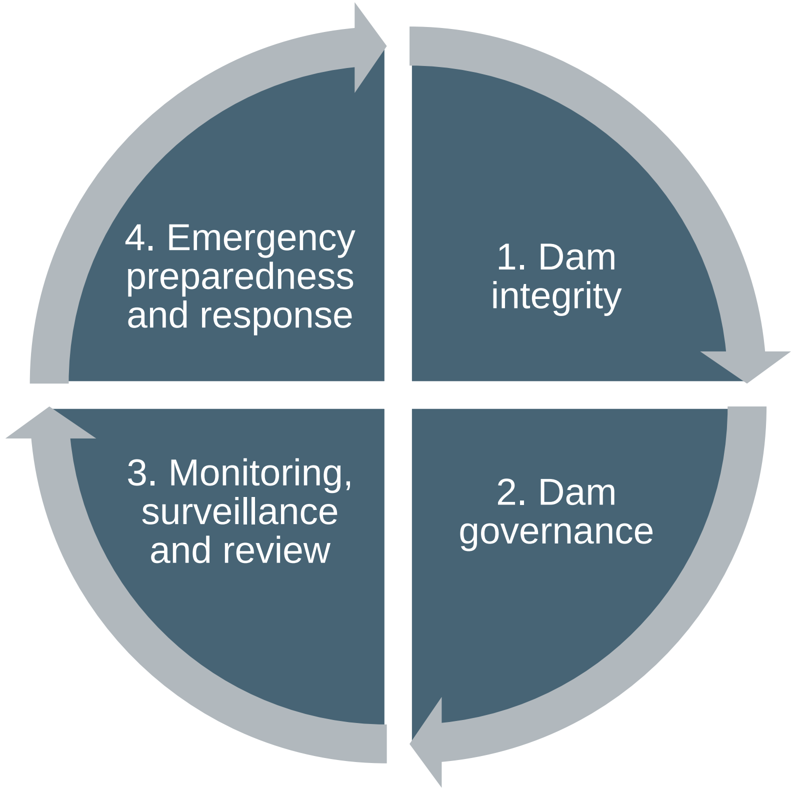
Part 3: Approach to dam risk management at BHP’s operations

Approach to dam risk management at BHP operations[1]

Maintaining dam integrity requires appropriate engineering design, quality construction, ongoing operating discipline and effective governance processes

- BHP's approach to dam risk management is a multi-dimensional process of continuous assessment focused on:
  1. Maintenance of dam integrity;
  2. Governance of dam facilities;
  3. Monitoring, surveillance and review; and
  4. Emergency preparedness and response.
- Technical, Group-level oversight of these processes is currently supported by our Resource Engineering Centre of Excellence and moving forward will be supported by our newly introduced Tailings Taskforce.



Group-level oversight and assurance

1. This approach applies only to BHP-operated dams with the specific details commensurate with risk.

1. Dam integrity

Dam integrity is an ongoing process of continuous assessment that must be maintained for the life of a tailings dam

Critical components to maintaining dam integrity include:

- **Design:** the basis of dam design is guided by design criteria specified through ANCOLD, CDA and local regulations taking account of the dam classification.
- **Construction:** quality assurance and quality control across all construction phases (from initial construction to dam lifts / expansions during operation).
- **Operations and maintenance:** operating and maintaining the dam in accordance with its design requirements.
- **Change management**: identifying, assessing and mitigating the impacts of any changes on dam design and integrity.
- **Monitoring, surveillance and review:** ensuring the dam is functioning as intended.

Olympic Dam Tailings Storage Facility
South Australia

2. Dam governance

Effective governance encompasses a range of aspects from change management to document management to appropriately qualified personnel with clear accountabilities

We have a number of specific roles across our assets to support the governance of our facilities:

Dam Owner	The Dam Owner is the BHP single point of accountability for maintaining effective governance and integrity of the dam(s) throughout the life-cycle. The Dam Owner is also accountable for ensuring adequate resources, processes and systems are in place.
Responsible Dam Engineer	The Responsible Dam Engineer, supports the Dam Owner as a qualified BHP individual accountable for maintaining overall engineering stewardship of the facility. Responsibilities include oversight of planning, design, operation, construction, maintenance and surveillance of dams on a site. The Responsible Dam Engineer must possess the requisite knowledge, skills and abilities to perform these responsibilities commensurate with dam risk.
Engineer of Record	The Engineer of Record is an independent, qualified professional engineer retained by the Dam Owner for the purpose of maintaining dam design and certifying dam integrity. The Engineer of Record will have suitable experience in the design and construction of dams commensurate with the consequence category of the dam, its type and its location. The Engineer of Record is generally a more experienced engineer who also supports the Dam Owner and the Responsible Dam Engineer on any other matters of a technical nature.

3. Monitoring, surveillance and review

Given tailings dams are dynamic structures, effective monitoring, surveillance and review is central to ongoing dam integrity and governance.

These processes span six dimensions with the specific details commensurate with the significance of the facility.

1. Monitoring systems
- For example this can include instrumentation such as piezometers, radar to monitor aspects such as water levels and stability.

2. Routine surveillance (Operators)
- 'On-going' observations related to the conditions and performance of the dam
- Frequency: daily to weekly depending on the dam

3. Dam inspections (Responsible Dam Engineer)
- Detailed inspection
- Visual observations
- Frequency: weekly to semi-annually depending on the dam

4. Dam safety inspections (external Engineer of Record)
- Detailed inspection by qualified dam safety engineer
- Visual observations
- Reviews instrumentation data and inspection records
- Review of the Operations, Maintenance, and Surveillance Manual (including emergency response)
- Frequency: annual

5. Dam safety reviews (external Qualified Professional Engineer)
- Comprehensive review against design criteria to ascertain adequacy of dam integrity
- Checks design, construction, performance, management, operations and emergency planning
- Frequency: every 5-10 years, depending on the dam classification and risk profile, could be more frequent in line with the recommendations provided by CDA Dam Safety Review process

6. Tailings Review Boards[1] (Multi-disciplinary Board of independent experts)
- Established, commensurate with dam significance, to review a range of subject matters including the current status of the dam; any proposed design changes and outcomes of any inspections or dam safety reviews
- Frequency of meetings depends on scope of review board, operating status of dam and level of dam risk

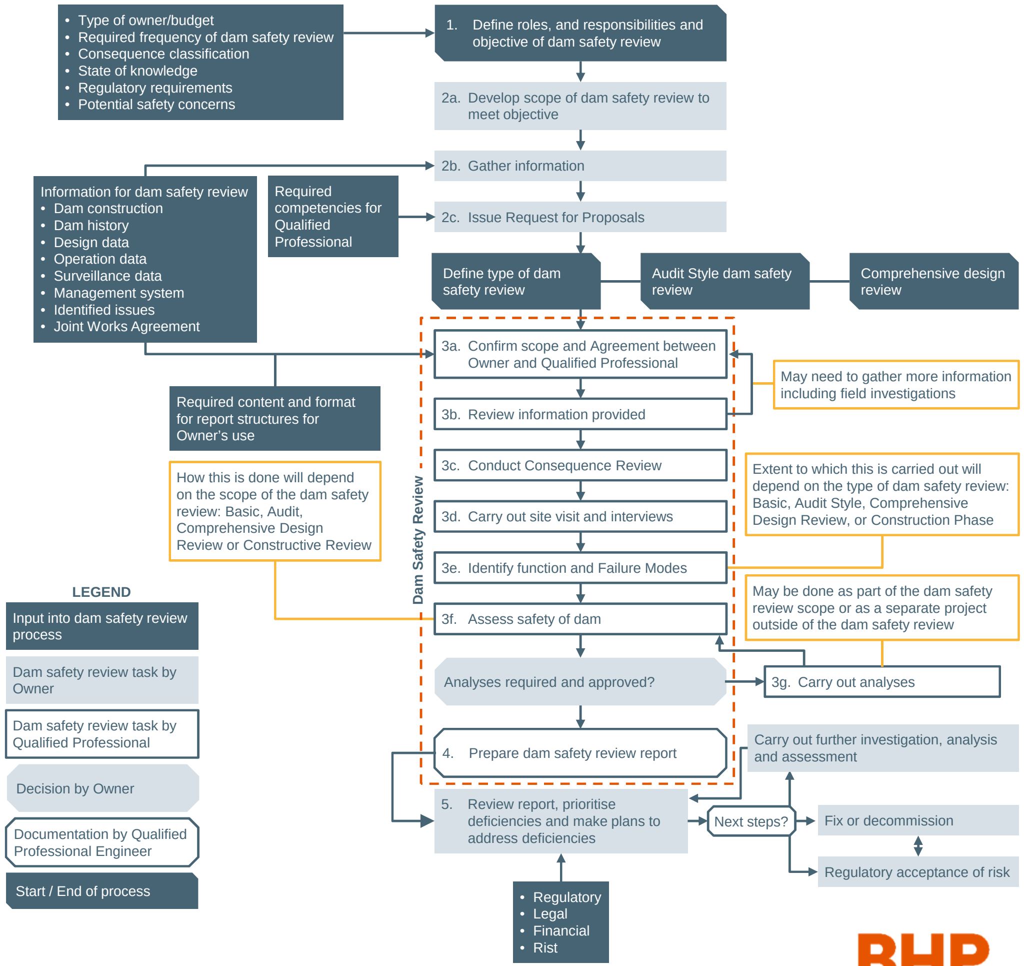
1. BHP assesses the dam classification, risk, and operational circumstances in determining whether to empanel a Tailings Review or Stewardship Board. Not all facilities will have Tailings Review or Stewardship Boards. Tailings Review or Stewardship Boards are either in place or in the process of being established for BHP operated Assets with Very High and Extreme classified tailings facilities.

3. Monitoring, surveillance and review

Dam Safety Reviews

- Dam Safety Reviews are systematic, detailed, external reviews of design, construction, maintenance, operation and governance processes that affect a dam's safety. They include a review of the dam break assessment and dam consequence classification.
- BHP has elected to apply the guidance provided by the CDA[1], the most recent and comprehensive guidance documents for this type of process in the industry.
- The review is led by an external Qualified Professional Engineer, who has the appropriate level of education, training and experience, with support and input from other technical specialists from fields which may include, for example, hydrology, geochemistry, seismicity, geotechnical or mechanical.
- An assurance statement is signed by the Qualified Professional Engineer as to the integrity of the dam.
- Frequency generally every 5-10 years commensurate with the consequence classification of the structure.

CDA process for DSRs



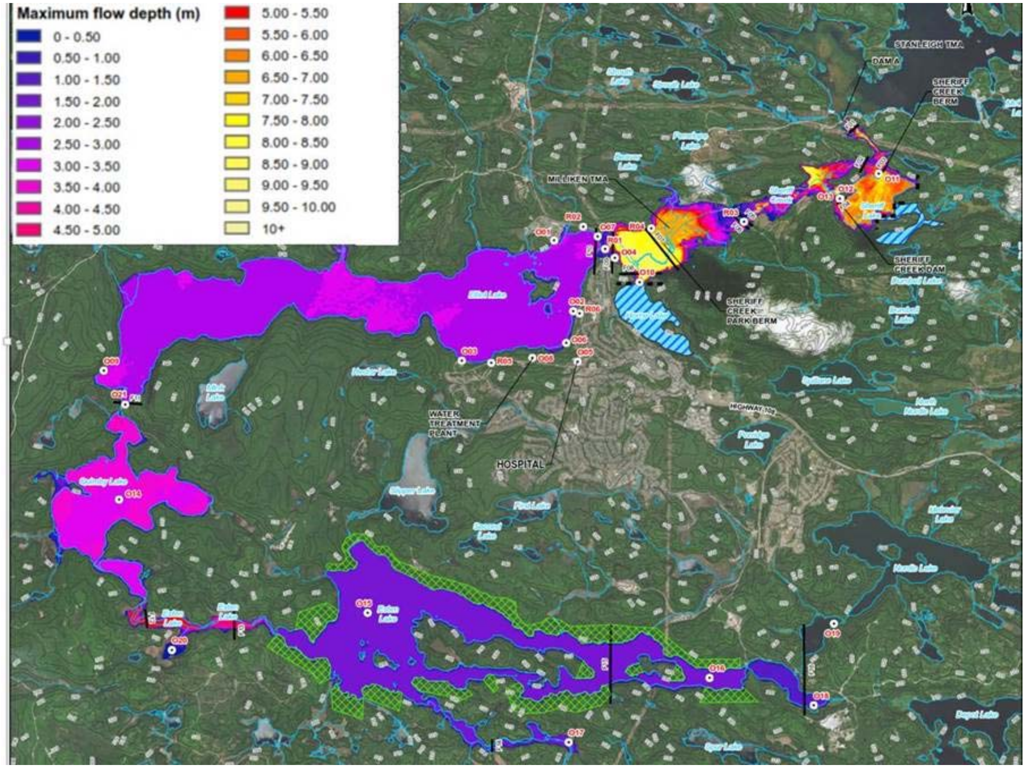
1. CDA Technical Bulletin: Dam Safety Reviews (2016).

4. Emergency preparedness and response

Emergency preparedness and response is a key element in our approach to dam risk management

Classification is based on the modelled, hypothetical most significant failure mode without controls – not on the current physical stability of the dam.

- Emergency response planning for our tailings facilities is designed to be commensurate with risk and includes:
  - **identifying and monitoring for conditions** and thresholds that prompt preventive or remedial action;
  - **assessing and mapping the potential impacts** from a hypothetical, significant failure including infrastructure, communities and environment, both on and offsite, regardless of probability;
  - **establishing procedures** to assist operations personnel responding to emergency conditions at the dam; and
  - **testing and training** ranging from desktop exercises to full-scale simulations. Desk top and field drills are scheduled at a frequency commensurate with the level of risk of the facility.



Example modelled, hypothetical significant failure scenario

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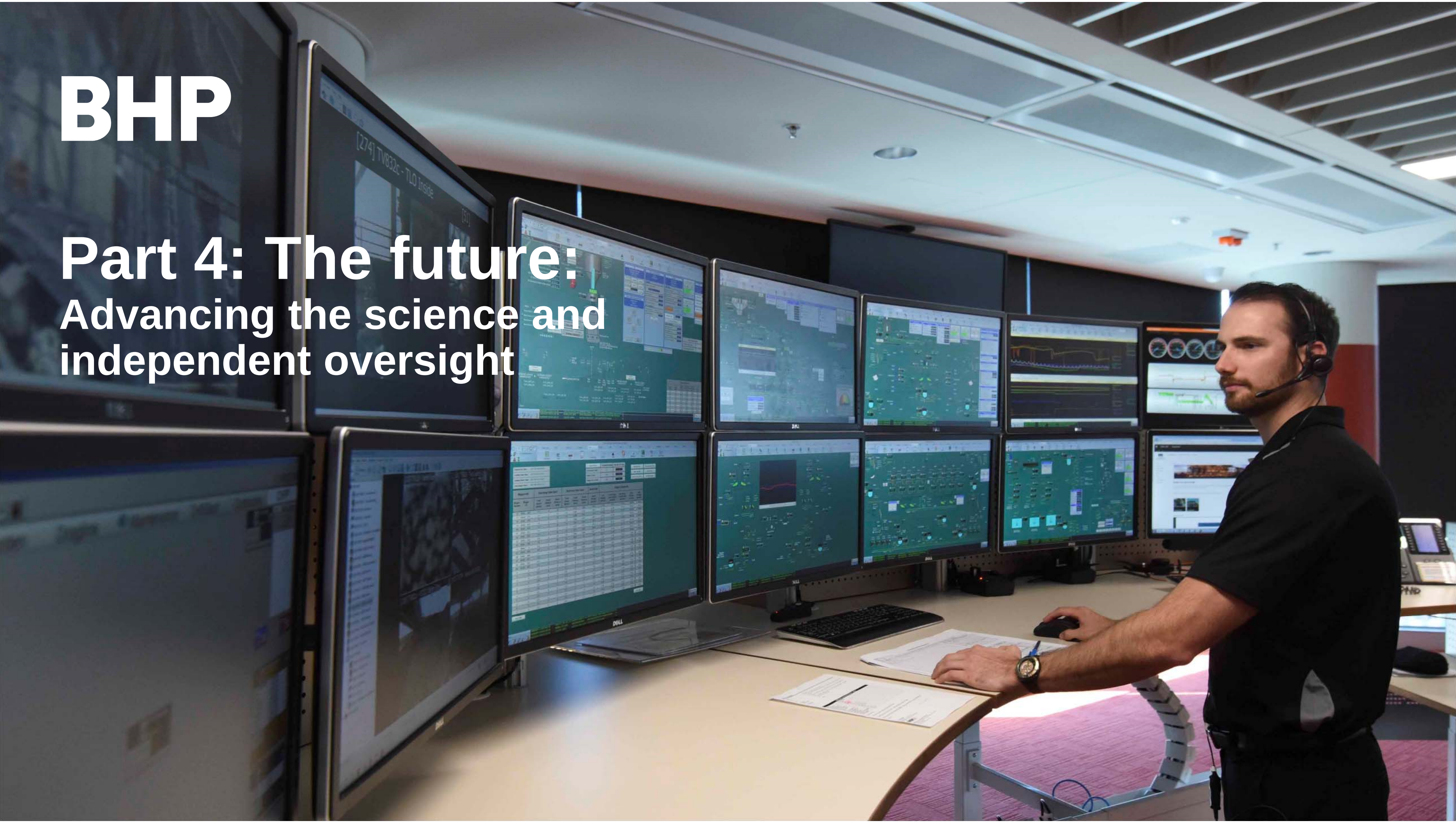
Part 4: The future:

Advancing the science and independent oversight



BHP Tailings Taskforce

Prior to Brumadinho we already had a significant focus on looking at how we could deliver a step change reduction in tailings risk. Brumadinho however has further strengthened our resolve.

BHP has now established a Tailings Taskforce.

The Taskforce will be accountable for further enhancing our focus on tailings including the continued improvement and assurance for BHP's operated tailings storage facilities, progressing our technology efforts and leading ongoing participation in the setting of new international tailings management standards.

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BHP tailings technology strategy

Accelerating the pathway to safer, more sustainable management

We get there through R&D in key workstreams…

…with the approach to de-risk technology options linked to Asset challenges

Our Goal

Reducing tailing dam failure risk by accelerating technology for safer, more sustainable tailings management.

Harnessing benefits including increased water recovery, reduced land disturbance and reduced closure costs.

WORKSTREAMS

Characterisation
In process & deposition

Monitoring
Real-time sensing & prediction

Dam Stabilisation
Active, legacy dam strengthening

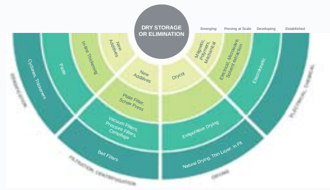
Tailing & Deposition
Reduce, Dewatering, Deposition

Closure
Reprocess, Reuse, Landform

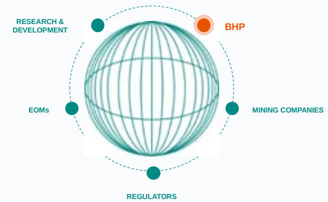
Avoid
In-situ extraction

APPROACH

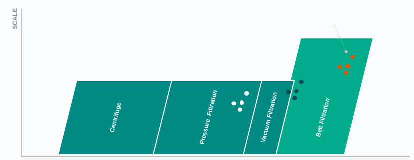
TECHNOLOGY OPTIONS



INDUSTRY COLLABORATION



TECHNOLOGY PLAYBOOK



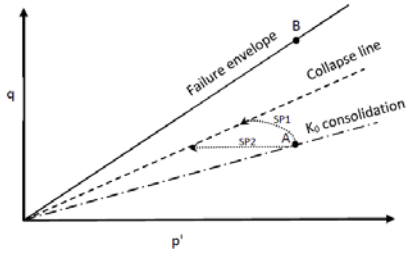
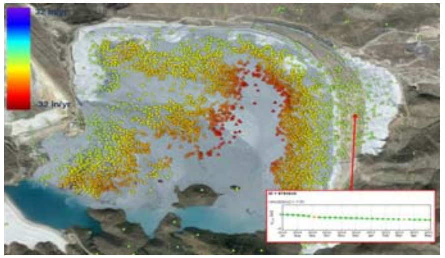
BHP tailings technology R&D

Building a portfolio view on BHP R&D investment

WORKSTREAMS	INDICATIVE OPPORTUNITIES
Characterisation *In process & deposition*	• Tailing Liquefaction 3 year R&D on critical state line methodology • Dry Tailing piggy back deposition 3 year R&D on geotechnical stability
Monitoring *Real-time sensing & prediction*	• Fundacion Chile 5 year R&D on real-time monitoring for early warning • 3 year Geomatics satellite sensing on dam movement for early warning • Digital Twin model 2 year R&D for real-time prediction on dam health
Dam Stabilisation *Active, legacy dam strengthening*	• Insitu dewatering (e.g. electro kinetics, blasting) • Bacteria inoculation for cementation
Tailing & Deposition *Reduce, Dewatering, Deposition*	• Coal tailings mechanical dewatering at Coal assets • Coal tailings alternate dewatering (e.g. electrokinetics, microwave) assessment • Tailing dewatering for dry deposition and tailing reduction
Closure *Reprocess, Reuse, Landform*	• Offset closure costs (e.g. reprocess tailings) • Remove and reuse (e.g. building construction materials) • Repurpose tailing landforms
Avoid *In-situ extraction*	• Innovative extraction, in-situ extraction

Collaborative research and innovation

WORKSTREAMS

	Characterisation	Monitoring	Innovation
			
RESEARCH	• Liquefaction Risk • Piggy Back Deposition	• CalTech Digital Twin • Fundacion Chile • Remote Sensing for movement	• Zero Waste Mining (tailings avoidance, repurpose, remediation)
IMPACT	• Static liquefaction understanding will lead to better and earlier predictors of instability • Moisture reduction and increasing pile density in TSF's will materially reduce liquefaction potential	• The integration of monitoring and sensing technologies into a digital platform will empower real-time risk management direct to our operational decision makers	• XPrize and its Chilean Mining Consortium sponsor, a partnership including BHP, aim to revolutionise mining to sustainably meet the resource needs of the planet. • Focus on tailing challenges to identify innovative and scalable technologies to catalyze zero waste mining
ACTIVITY	• Foundational research into material bulk strength under static loading and precursors for static liquefaction. • Piggy back deposition – impact on paste or filtered tailings on conventional tailings footprints.	• Sensor integration into an early warning operations reaction digital platform.	• Crowdsource innovative solutions to mining industry tailing challenges through the XPrize design and competition process. • Competition design phase underway. • Zero Waste Mining (tailings) XPRIZE competition launch scheduled Q2 2020.

Industry collaboration

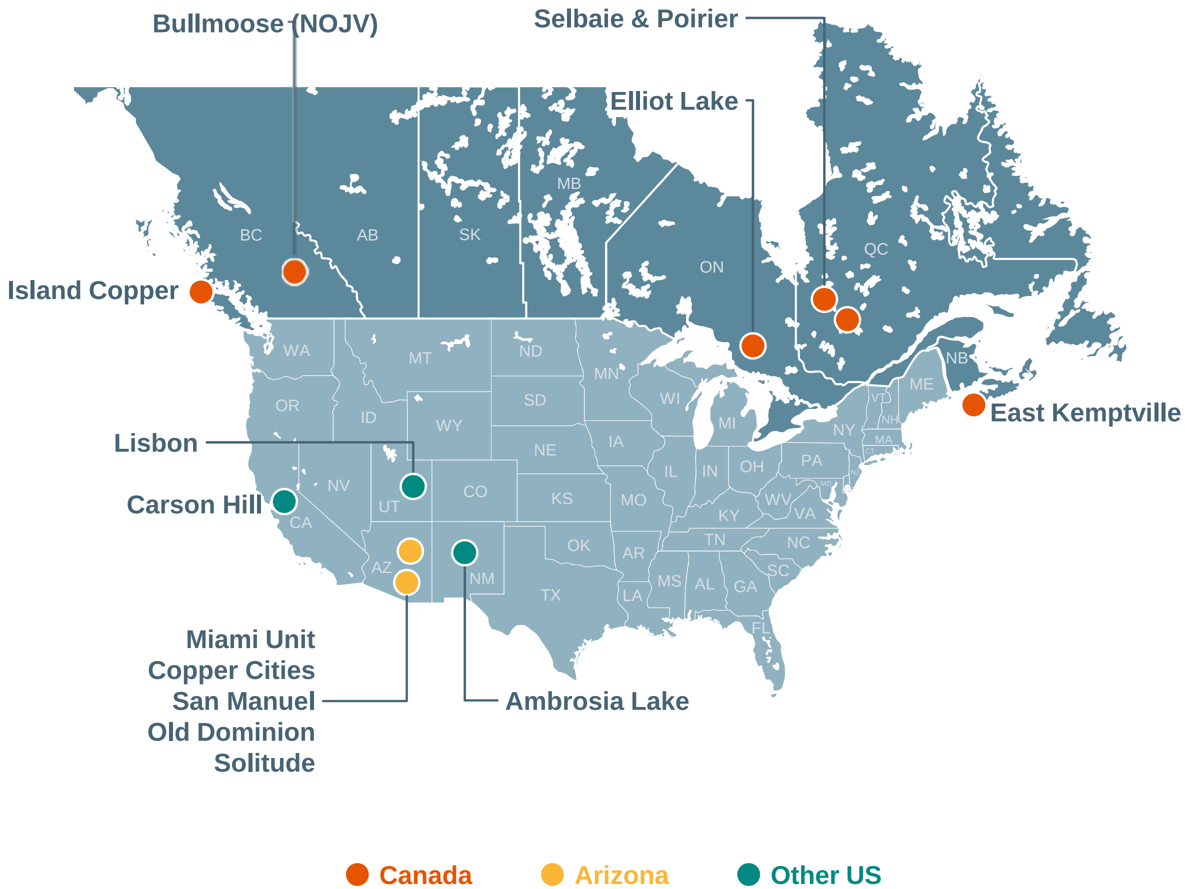
BHP welcomes a common, international and independent body to oversee integrity of construction and operation of all tailings storage facilities across the industry. In addition, BHP supports calls for greater transparency in tailings management disclosure and will work with the industry to make sure the disclosure is consistently applied and informs better tailings dam stewardship.

- BHP continues to engage with a range of organisations including ICMM, ICOLD and the UN Environment Programme.
- The International Council of Mining and Metals (ICMM), Principles for Responsible Investment and United Nations Environment Programme have agreed to lead a review to establish an international standard for the safe management of tailings dams that can be applied to all tailings dams wherever they are located and whoever operates them.
- Professor Bruno Oberle was recently appointed to oversee every aspect of the review and prepare a report which is expected to be published by the end of the year. Professor Oberle is Chair for Green Economy and Resource Governance and Academic Director of the International Risk Governance Center at L'Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland, a panel member of the International Resource Panel and a member of the Leadership Council of the Sustainable Development Solutions Network. He was previously the Swiss Secretary of State for the Environment and Director of the Swiss Federal Office for the Environment.
- Set up in response to the Brumadinho tragedy in Brazil, the review will be informed by evidence and lessons from this dam failure as well as earlier mine tailings dam failures.

Case Study: North American Closed Sites tailings facilities

North American Closed Sites tailings portfolio

- The North American Closed Sites portfolio consists of 32 operated Tailings Storage Facilities distributed across 19 mine sites at locations in the US (Arizona, California, New Mexico, Utah) and Canada (British Columbia, Nova Scotia, Ontario and Quebec).
- In addition to tailings facilities, there are also other dams that don't contain tailings however still require management.
- All the facilities are inactive and in various states of regulatory closure, from active reclamation to long-term care and maintenance.
- The facilities range in age from 1880s (Old Dominion) to 1990s (Elliot Lake).
- Many of the structures have been inactive for 30 years.



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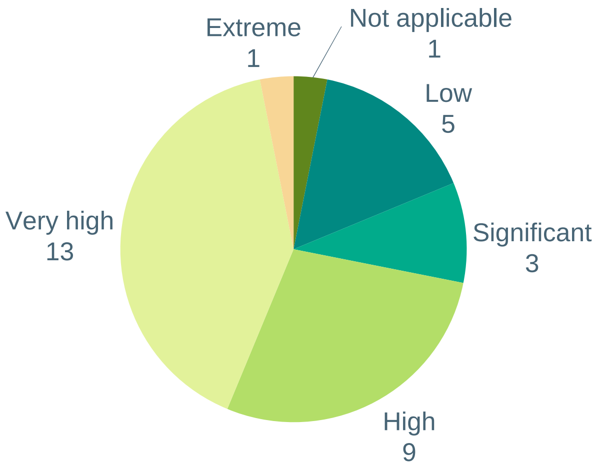
North American Closed Sites tailings portfolio

Classification is based on the modelled, hypothetical most significant failure mode without controls – not on the current physical stability of the dam.

- North American Closed Sites account for over half of BHP's operated very high and extreme classified TSFs.
- Given these facilities are inactive, the most probable failure modes for these facilities generally arise from environmental factors including extreme precipitation and extreme seismic events.
- The dam classifications driven by the modelled most significant, possible failure scenarios within the closed sites portfolio cover a range of potential impact triggers from community to environmental impacts.

CDA Classification of Closed Sites TSFs[1,2]

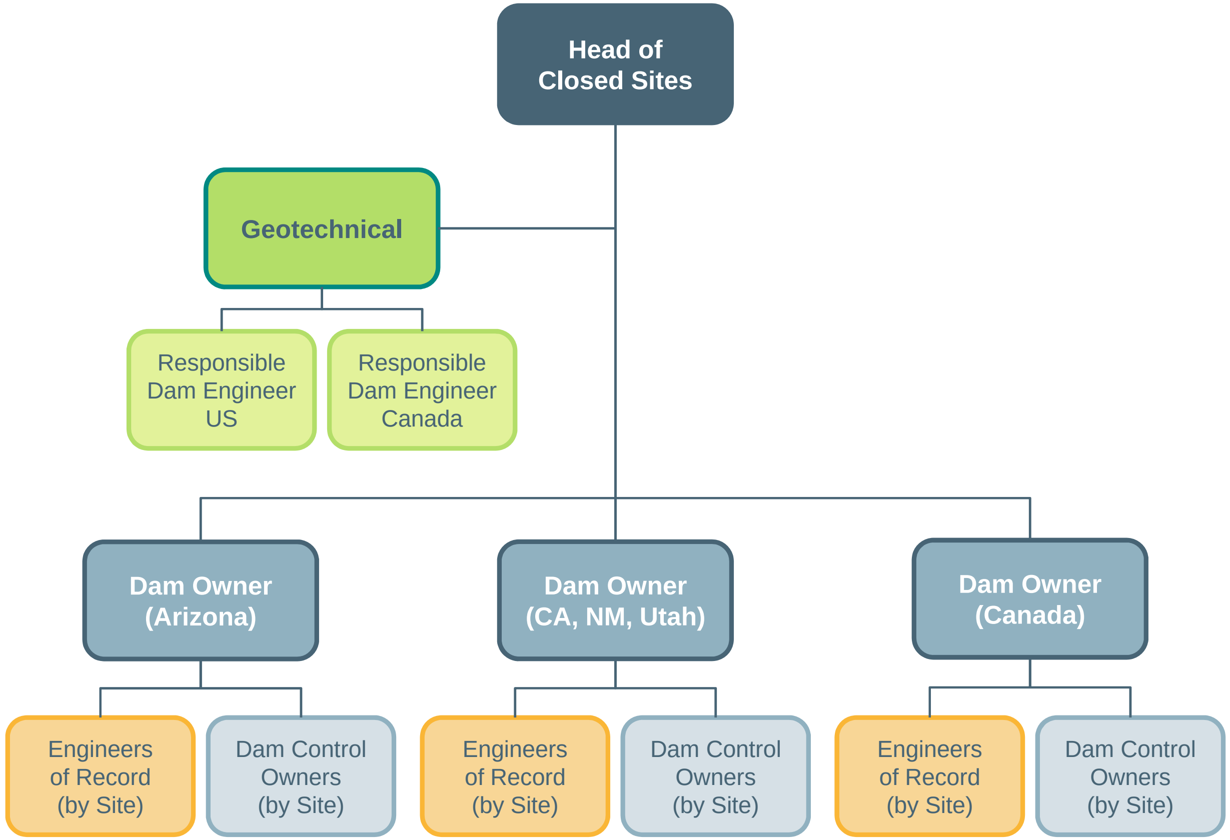


1. These data are for operated tailings facilities only. The number of tailings storage facilities is calculated based on the definition agreed by the International Council on Mining and Metals Tailings Advisory Group in response to the Church of England information request which differs to the definition applied to our February disclosure. We keep this definition under review. The classification of the tailings facilities is based on the most recent classification of the facilities by the Engineer of Record. This is subject to change as ongoing reviews are conducted . Closed sites also have a portfolio of other containment structures which have not been included in these figures.
2. Tiger TSF which is part of San Manuel and Miami No 2 which is part of Miami Unit have yet to be classified by an Engineer of Record however have been assessed as low based on internal classifications One tailings facilities is not considered a dam and therefore not subject to classification (labelled Not applicable): Island Copper TSF in Canada, acquired in the 1980s. Tailings at Island Copper were deposited in the ocean under an approved license and environmental impact assessment. This historic practice ceased in the 1990s. BHP has since committed to not dispose of mine waste rock or tailings in river or marine environments.

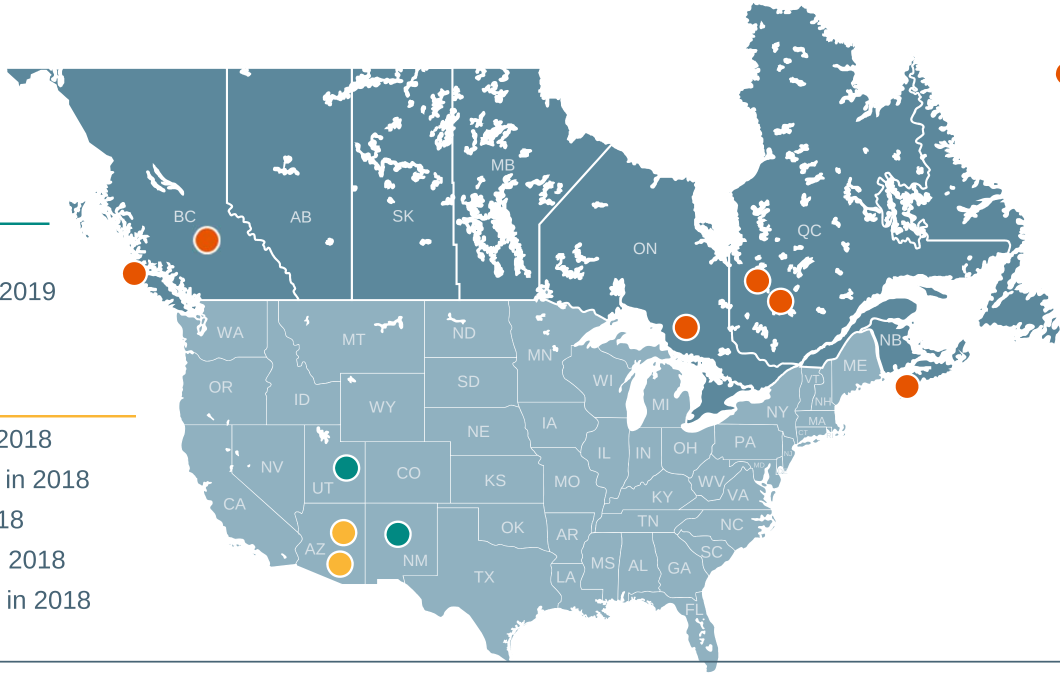
North American Closed Sites dam governance

A clear approach to dam governance is in place across the North Americans Closed Sites portfolio

- Dam Owners have been assigned for each key grouping of sites specifically to provide a single point of accountability for all aspects concerned with dam governance and risk management.
- Qualified, external Engineers of Record undertake annual detailed dam safety inspections, classify the dams and provide technical advice while Dam Control Owners are internal resources responsible for undertaking more frequent inspections to assess controls and monitoring is effective. There are Engineers of Record and Dam Control Owners for each site.
- In addition a qualified Geotechnical team provides internal technical support across the portfolio.



Dam safety reviews[1] (DSRs)



Other US

Lisbon – DSR completed April 2019

Ambrosia Lake – DSR completed April 2019

Arizona

Miami Unit – DSR completed in 2018

Copper Cities – DSR completed in 2018

Solitude – DSR completed in 2018

San Manuel – DSR completed in 2018

Old Dominion – DSR completed in 2018

Canada

Elliot Lake – Initial **DSR** in 1999; subsequent **DSR** completed in 2007 and 2013. Planned updates based on consequence classification rating in Canadian Dam Association framework.

East Kemptville – DSR completed in 2007 and 2014

Selbaie – DSR completed in 2015

Poirier – Geotechnical Assessment completed 2018; **DSR** scheduled 2019

Island Copper – Geotechnical Assessment[2] completed in 2017

Bullmoose (NOJV) – DSR conducted by **Teck** in 2016

- Dam Safety Reviews are a critical process for deeply understanding the status of the closed sites dam portfolio.
- The outcomes of the DSRs to date have **not** identified any deficiencies which have safety implications.
- In addition, the DSRs have confirmed that the regular dam monitoring, maintenance and surveillance activities …*have been efficient and effective in identifying maintenance issues promptly and resolving them quickly.*

1. Tiger TSF which is part of San Manuel and Miami No 2 which is part of Miami Unit are scheduled to be reviewed.
2. Island Copper TSF in Canada (a submarine tailings deposit which occurred prior to BHP's acquisition, now inactive) is not considered a dam and therefore a geotechnical assessment rather than a DSR has been undertaken.

Example of an emergency drill: Elliot Lake

The Emergency Response Drill for Elliot Lake involved a two-step process so that the community was engaged, aware and available

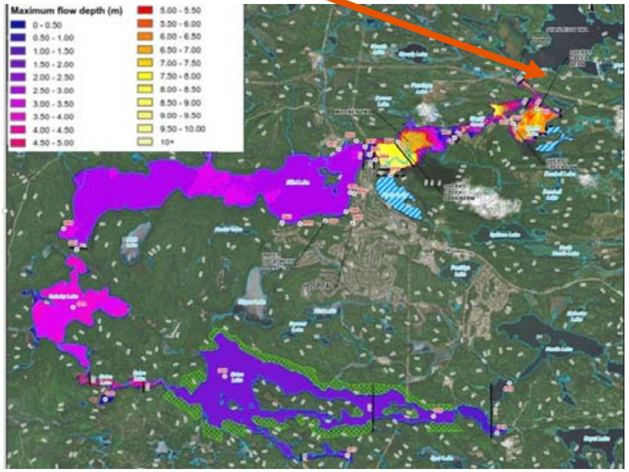
First step: a community emergency planning workshop

- The purpose of the workshop was to introduce BHP's emergency planning process to the community of Elliot Lake and to assess BHP and community emergency response readiness.
- External participants included representatives from municipal governments, First Nations, regulatory agencies, emergency response agencies and public health agencies.

Second step: execution of the emergency drill

- The emergency scenario was based on a failure at the Stanleigh tailings facility causing possible:
  - washout of the Stanleigh Dam Road and impacts to a garden centre;
  - impacts to the drinking water supply to City of Elliot Lake;
  - disruption of power and gas and land-based communication; and
  - rise of water levels in regional lakes.
- Participants in the drill included BHP, City of Elliot Lake, Algoma Emergency Services, Northshore Search and Rescue, Algoma Health, local Ontario Provincial Police, Ministry of Environment and Canadian Nuclear Safety Commission (notifications only).
- The drill demonstrated successful activation, mobilisation and communications between BHP and City of Elliot Lake Emergency Operations Centre with a full field response achieved.
- Lessons learned from the activity have been captured and are intended to be incorporated to enhance preparedness.

Stanleigh Dam A



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Appendix

Comparison ANCOLD and CDA Dam Classifications

CDA (2007)	ANCOLD Guidelines on Tailings Dams (2012)
EXTREME	Extreme
VERY HIGH	High A High B
HIGH	High C
SIGNIFICANT	Significant
LOW	Low
CDA does not have this category	Very Low

BHP