



2021 SME Minnesota Conference

April 13-15, 2021 | ONLINE

The Rapidly Evolving World of Tailings Management – Where are We Headed?

Kurt J. Schimpke, PE
Barr Engineering Co.
Minneapolis, MN

agenda

- where we've been
- where we're headed

where we've been

- approximately 18,000 tailings storage facilities worldwide
(Church of England, 2020)

where we've been

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- vast majority have been operated safely for many years

where we've been

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- vast majority have been operated safely for many years
- tailings dam failures are rare

where we've been

- approximately 18,000 tailings storage facilities worldwide (Church of England, 2020)
- vast majority have been operated safely for many years
- tailings dam failures are rare
- but recent failures have had a significant affect on industry trajectory

where we've been

2014

August 4, 2014

Mount Polley Dam Breach

2015

2016

2017

2018

2019

2020



from Morgenstern et al (2015)

- 24M m³ of tailings released
- environmental damage
- no fatalities

where we've been

2014	August 4, 2014	Mount Polley Dam Breach
2015	January 30, 2015	Mount Polley Failure Report
2016		
2017		
2018		
2019		
2020		

Independent Expert Engineering Investigation and Review Panel

Report on Mount Polley Tailings Storage Facility Breach

- design did not appreciate potential for GLU to behave undrained
- “business as usual cannot continue”
- advocated for use of BAPs and BATs
- eliminate surface water
- promote unsaturated conditions
- dilative conditions through compaction

where we've been

2014

August 4, 2014

Mount Polley Dam Breach

2015

January 30, 2015

November 5, 2015

Mount Polley Failure Report

Fundao Dam Breach

2016

2017

2018

2019

2020



- 19 fatalities
- environmental damage
- deviations from original design, resulting in loose, saturated tailings and slimes encroachment
- lateral extrusion trigger, exacerbated by earthquake
- result – renewed focus on liquefaction

where we've been

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2015	January 30, 2015 November 5, 2015	Mount Polley Failure Report Fundao Dam Breach
2016		
2017	October 2017	MEND Document Released
2018		
2019		
2020		



**Study of Tailings
Management
Technologies**
MEND Report 2.50.1

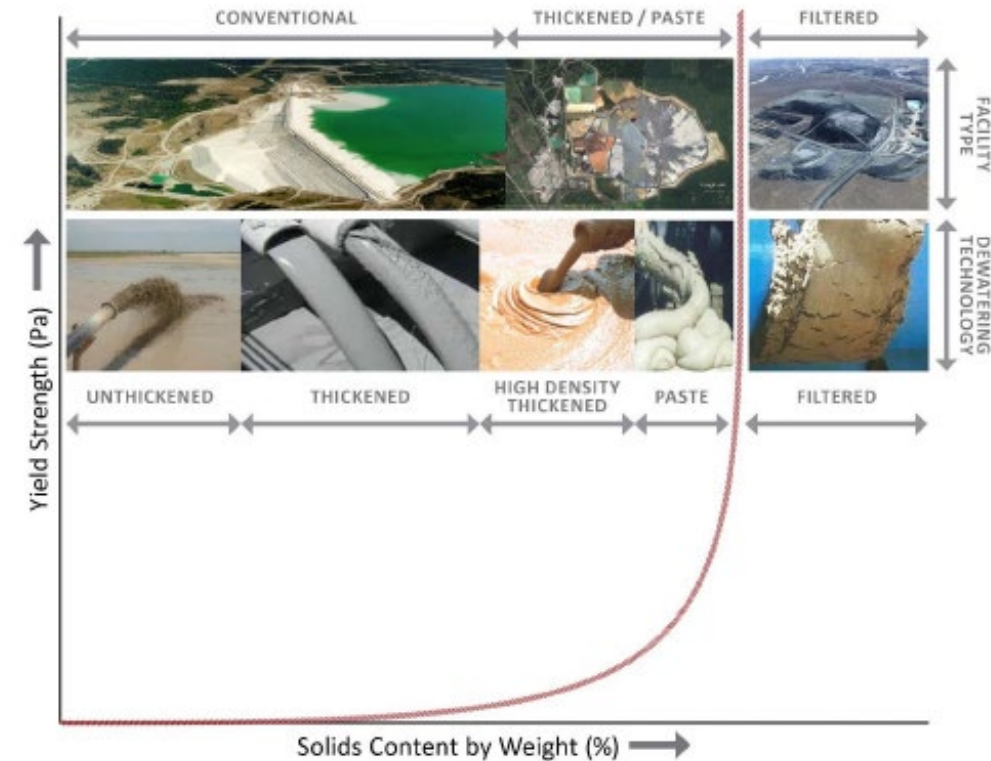
This work was done on behalf of the Mine Environment Neutral Drainage
(MEND) Program and sponsored by:
The Mining Association of Canada (MAC) and MEND

October 2017

where we've been

2014	August 4, 2014	Mount Polley Dam Breach
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2016		
2017	October 2017	MEND Document Released
2018		
2019		
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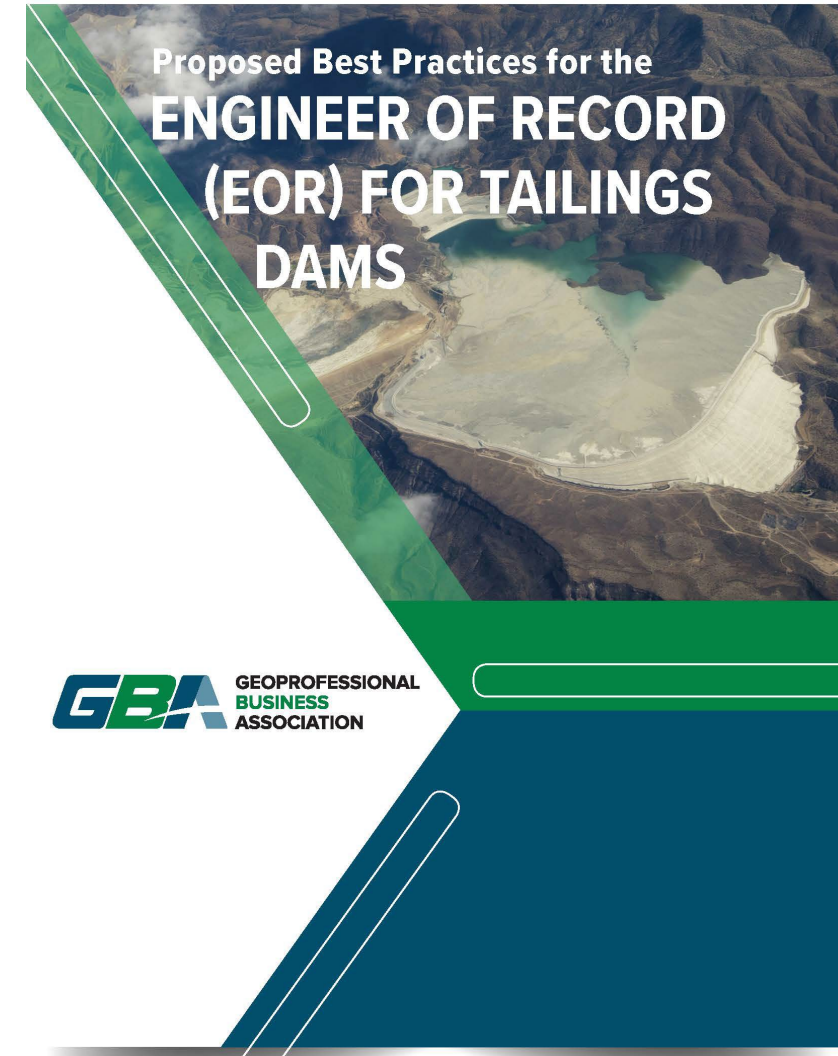
Figure 1.1 Dewatered Tailings Continuum and Corresponding Facility Types



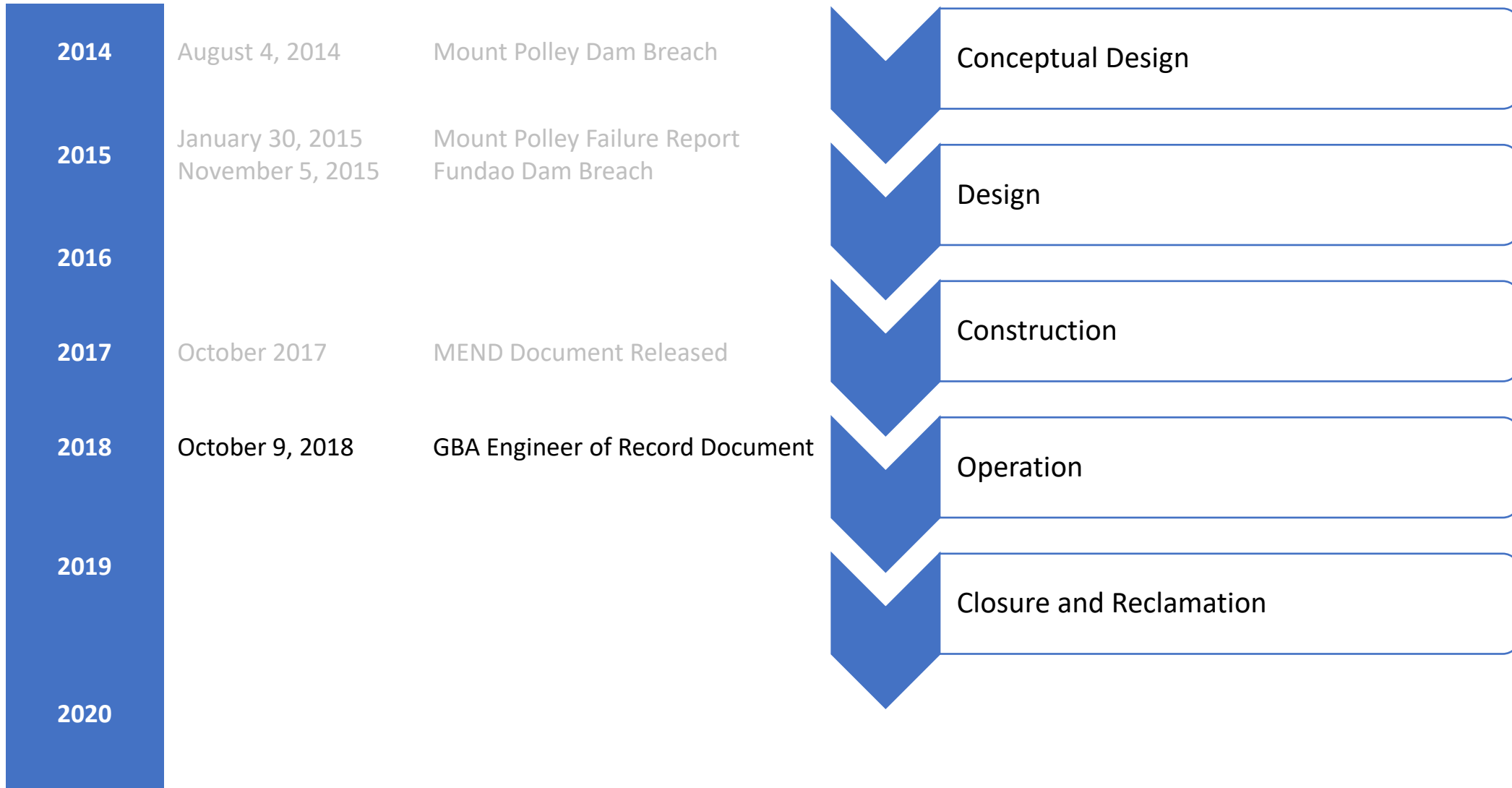
MEND (2017)

where we've been

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where we've been



where we've been

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2018	October 9, 2018	GBA Engineer of Record Document
2019	January 25, 2019	Brumadinho (Feijão) Dam Breach
2020		



- 270 fatalities
- environmental damage
- liquefaction due to creep and rainfall (loss of suction)
- upstream construction ban in Brazil
- spurred Global Industry Standard on Tailings Management

where we've been

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2020		

TECHNICAL BULLETIN: TAILINGS DAM BREACH ANALYSES

DRAFT 8.01

DRAFT

Technical Bulletin:

Tailings Dam Breach Analyses

February 15, 2019

Prepared by

Tailings Dam Breach Working Group

Canadian Dam Association

where we've been

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CANADIAN DAM ASSOCIATION
TECHNICAL BULLETIN: TAILINGS DAM BREACH ANALYSES (Draft V8.01)
FEBRUARY 2019



Table 6-1: Tailings Dam Breach Analyses Cases (Small et al., 2017)

Supernatant pond near the dam crest or the breach present?	Potential for tailings runout from the breach area as a result of flow liquefaction ¹ exists?	
	Yes	No
Yes	<u>Case 1A – Liquefied Tailings with a Pond:</u> Dam breach with flow of fluids and eroded, and liquefied flowable tailings contributing additional volume of materials released	<u>Case 1B – Non-Liquefied tailings with a Pond:</u> Dam breach with eroded tailings only, transported and deposited by the flow of fluids
No	<u>Case 2A – Liquefied tailings without a Pond:</u> Dam breach resulting from slope failure with liquefied flowable tailings as mudflow or landslide (depending on the degree of saturation)	<u>Case 2B² – Non-Liquefied tailings without a Pond:</u> Slope failure of the dam

where we've been

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2020		

Individualised letter to Mining company CEO/Chair
Address
Address
Address

5th April 2019

Re: Urgent request for information concerning tailings dam management

We write as 96 investors in the mining sector, who together represent over \$10.3 trillion in assets under management. This urgent engagement is being led by the Church of England Pensions Board and Swedish Council on Ethics for the AP Funds and backed by the UN-supported Principles for Responsible Investment (PRI).

The tragic loss of life from the Brumadinho and Samarco catastrophic tailings dam failures highlighted the devastating consequences when something goes wrong.

As responsible investors, we are committed to working with the mining sector to ensure that verifiable best practice standards are developed, implemented and maintained. To enable proper engagement on tailings dam management we need to assess the risks and the current state of tailings dam facilities that individual mining companies are associated with and/or have responsibility for, whether under construction, operation or retired/decommissioned.

Disclosure Request:

As institutional investors in the mining industry and in the absence of common public reporting standards on tailings storage facilities we respectfully request that you provide specific disclosures of all the tailings facilities of your company, as set out below. We ask that you provide this information, in accordance with the disclosure request included below (Annex 2), in table format. This disclosure should also include:

where we've been

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2020	June 15, 2020	Mount Polley Disciplinary Hearings

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[PMN Mining](#) / [PMN Business](#)

Three engineers to face disciplinary hearings in Mount Polley disaster


The Canadian Press

Sep 26, 2018 • September 26, 2018 • 2 minute read

VANCOUVER — The regulatory body for engineers in British Columbia is alleging negligence or unprofessional conduct against three engineers after the 2014 collapse of a tailings dam at the Mount Polley mine.

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TAILENG RESEARCH CENTER



Tailings and Industrial waste ENGINEERING research center
(TAILENG)



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where we've been

2014	August 4, 2014	Mount Polley Dam Breach	TOPIC I:	AFFECTED COMMUNITIES
2015	January 30, 2015 November 5, 2015	Mount Polley Failure Report Fundao Dam Breach	TOPIC II:	INTEGRATED KNOWLEDGE BASE
2016			TOPIC III:	DESIGN, CONSTRUCTION, OPERATION AND MONITORING
2017	October 2017	MEND Document Released	TOPIC IV:	MANAGEMENT AND GOVERNANCE
2018	October 9, 2018	GBA Engineer of Record Document	TOPIC V:	EMERGENCY RESPONSE AND LONG-TERM RECOVERY
2019	January 25, 2019 February 15, 2019 April 5, 2019	Brumadinho (Feijão) Dam Breach CDA Dam Breach Document Tailings Dam Disclosure Request	TOPIC VI:	PUBLIC DISCLOSURE AND ACCESS TO INFORMATION
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PREAMBLE

The Global Industry Standard on Tailings Management (herein 'the Standard') strives to achieve the ultimate goal of zero harm to people and the environment with zero tolerance for human fatality. It requires Operators to take responsibility and prioritise the safety of tailings facilities, through all phases of a facility's lifecycle, including closure and post-closure. It also requires the disclosure of relevant information to support public accountability.

Issues have arisen in the development of the Standard that are difficult to translate into an auditable industry Standard for Operators. These issues are more appropriately addressed through national and/or state level regulatory authorities, or through multilateral agencies working with the industry. For example, it is recognised that more work needs to be done by national and/or state level regulators to develop mechanisms that enable the identification, maintenance and/or restoration of abandoned or 'orphaned' facilities.

The Standard provides a framework for safe tailings facility management while affording Operators flexibility as to how best to achieve this goal. For auditing and certification purposes, the Standard includes the Preamble, the Requirements, the Glossary and Annexes. Unless otherwise specified, the Requirements of the Standard are directed to the Operator. The Requirements apply to individual facilities as defined in the Glossary, and are all intended to apply and be auditable.

Conformance with the Standard does not displace the requirements of any specific national, state or local governmental statutes, laws, regulations, ordinances, or other government directives. Operators are expected to conform with the Requirements of the Standard not in conflict with other provisions of law.

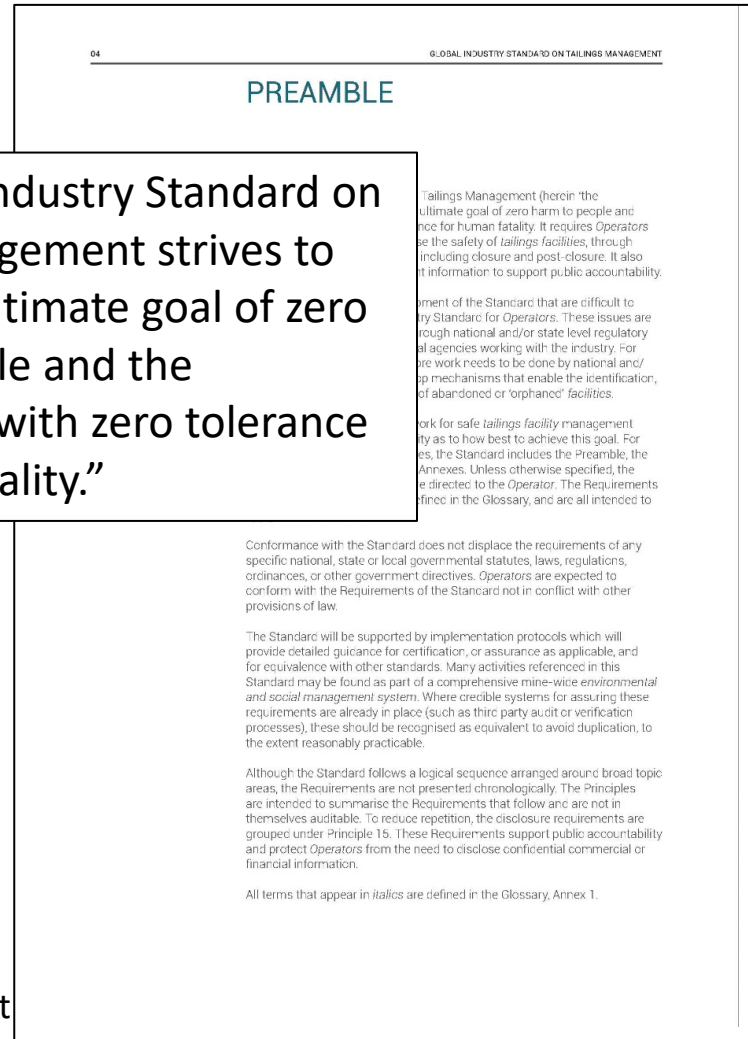
The Standard will be supported by implementation protocols which will provide detailed guidance for certification, or assurance as applicable, and for equivalence with other standards. Many activities referenced in this Standard may be found as part of a comprehensive mine-wide environmental and social management system. Where credible systems for assuring these requirements are already in place (such as third party audit or verification processes), these should be recognised as equivalent to avoid duplication, to the extent reasonably practicable.

Although the Standard follows a logical sequence arranged around broad topic areas, the Requirements are not presented chronologically. The Principles are intended to summarise the Requirements that follow and are not in themselves auditable. To reduce repetition, the disclosure requirements are grouped under Principle 15. These Requirements support public accountability and protect Operators from the need to disclose confidential commercial or financial information.

All terms that appear in *italics* are defined in the Glossary, Annex 1.

where we've been

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04

GLOBAL INDUSTRY STANDARD ON TAILINGS MANAGEMENT

PREAMBLE

“The Global Industry Standard on Tailings Management strives to achieve the ultimate goal of zero harm to people and the environment for

“The Standard provides a framework for safe tailings facility management while affording the Operators flexibility...”

Tailings Management (herein ‘the Standard’) is the ultimate goal of zero harm to people and the environment for human fatality. It requires Operators to ensure the safety of tailings facilities, through including closure and post-closure. It also provides information to support public accountability.

Implementation of the Standard that are difficult to achieve through national and/or state level regulatory agencies working with the industry. For work needs to be done by national and/or local mechanisms that enable the identification, and management of ‘orphaned’ facilities.

Tailings facility management must achieve this goal. For the Standard includes the Preamble, the Requirements, and the Operator. The Requirements are necessary, and are all intended to

meet the requirements of any applicable laws, regulations, standards, and other requirements. Operators are expected to ensure that the Standard does not conflict with other

on protocols which will provide detailed guidance for certification, or assurance as applicable, and for equivalence with other standards. Many activities referenced in this Standard may be found as part of a comprehensive mine-wide environmental and social management system. Where credible systems for assuring these requirements are already in place (such as third party audit or verification processes), these should be recognised as equivalent to avoid duplication, to the extent reasonably practicable.

Although the Standard follows a logical sequence arranged around broad topic areas, the Requirements are not presented chronologically. The Principles are intended to summarise the Requirements that follow and are not in themselves auditable. To reduce repetition, the disclosure requirements are grouped under Principle 15. These Requirements support public accountability and protect Operators from the need to disclose confidential commercial or financial information.

All terms that appear in *italics* are defined in the Glossary, Annex 1.

So where are we headed?

continued call for safety and transparency



DISCLOSURES

This portal brings together all of the disclosures that mining companies have made about their tailings storage facilities. It gives communities, investors, regulators and the media unprecedented access to information about mine waste.



98

MINING COMPANIES



162

PARTNER COMPANIES



304

MINING OPERATORS



764

MINE SITES



1938

TAILINGS STORAGE
FACILITIES

E-MAIL

✉ tailingsdam@grida.no



continued call for safety and transparency



public corporate commitment

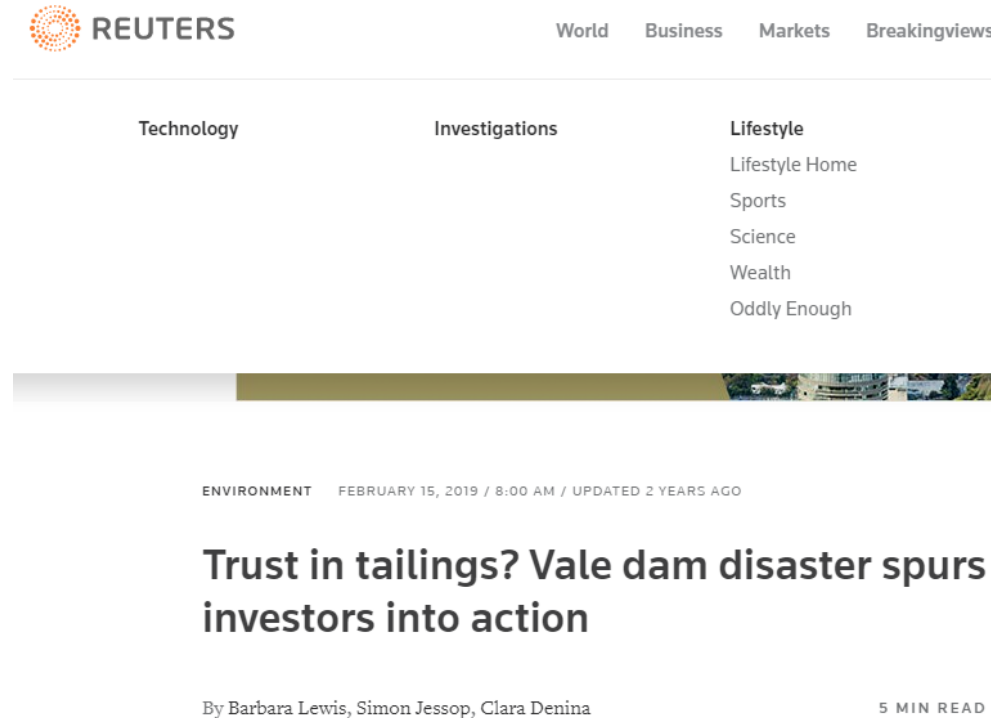


Tailings Management and Stewardship Summary

Affiliates of our company currently operate 18 tailings storage facilities (TSFs), 16 in the U.S. and two in Peru, and manage 58 in the U.S. that are inactive or reclaimed. Our inventory of TSFs comprises 13 active and 52 inactive or reclaimed facilities with an upstream design, five active and five inactive with a centerline design, and one reclaimed facility with a downstream design. After a detailed review of corporate records, we have recently increased the number of reported facilities to account for legacy operations that were reclaimed several decades ago.

continued investor and insurer attention

- PRI will develop investor expectations
- UNEP will drive government support
- Global Standard compliance may be a requirement for insurability
- some large mining companies will self-insure



adoption of BATs and BAPs

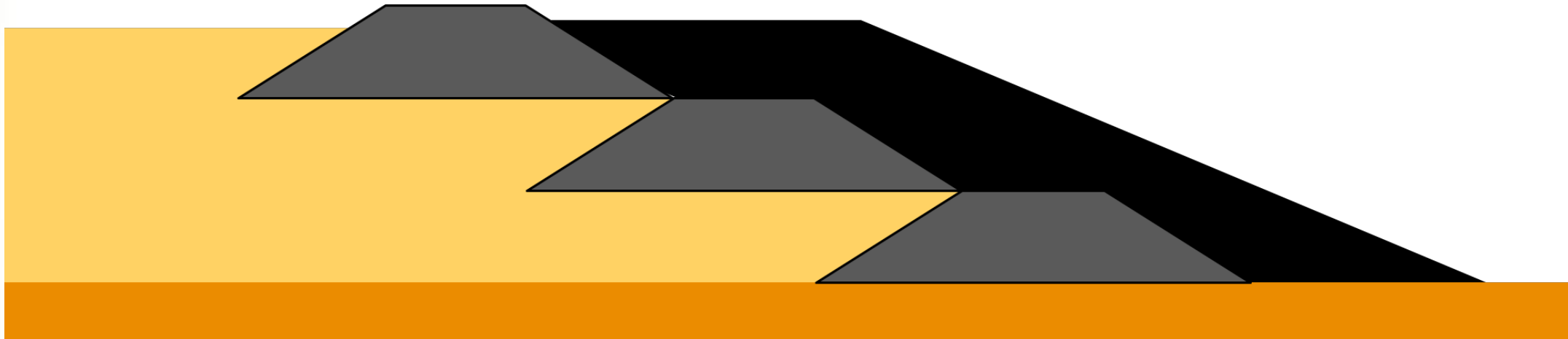
- tailings dewatering
- eliminating surface water
- establishing dilative conditions



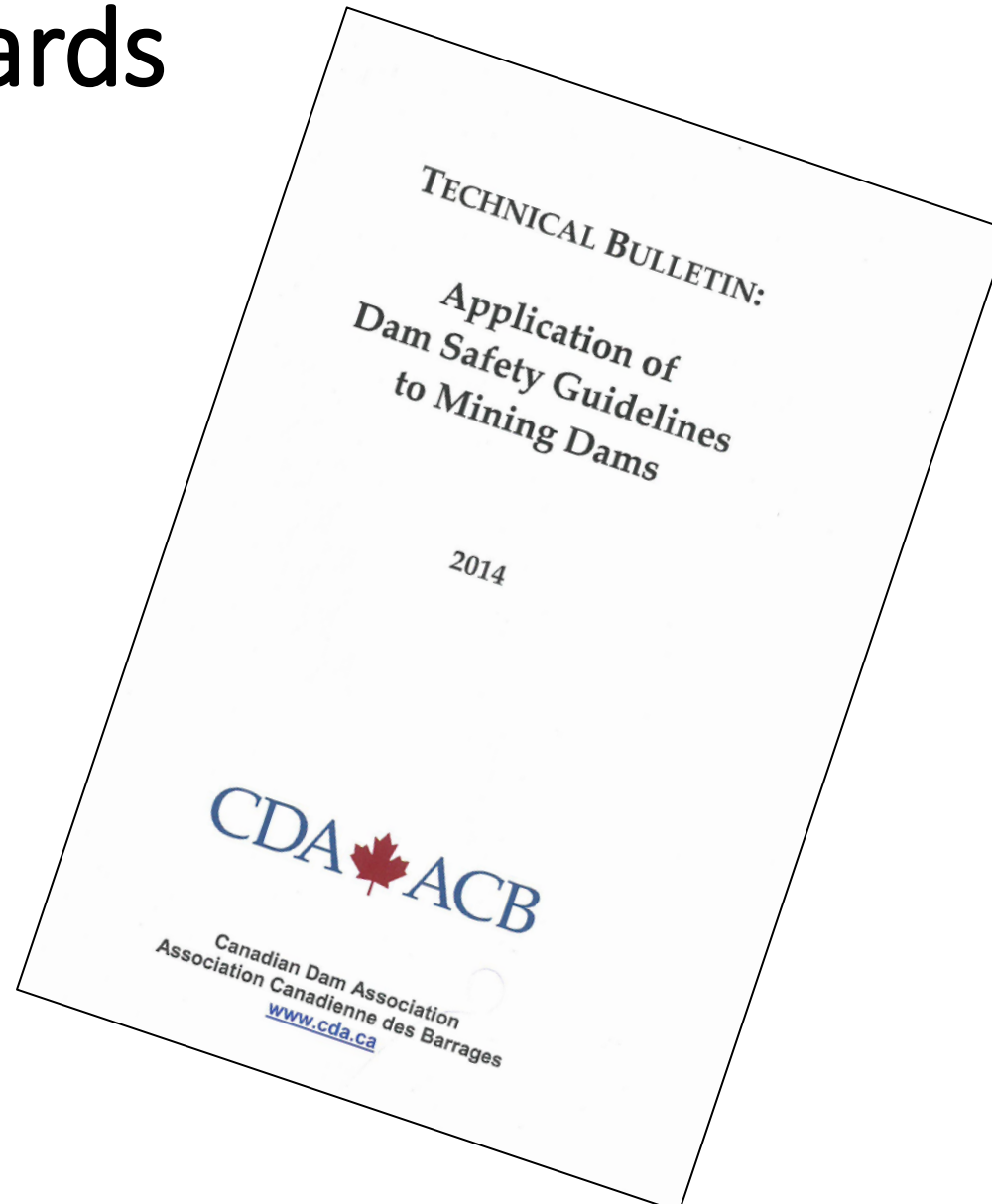
https://www.hecla-mining.com/responsible_mining/tailings-management-is-a-top-company-priority/

facility retrofits

- buttressing
- soil improvement
- seepage cutoffs
- move towards BATs and BAPs



increasing number of guidelines and standards



increasing number of guidelines and standards



increasing number of guidelines and standards



DRAFT REVISION

TECHNICAL BULLETIN: APPLICATION OF DAM SAFETY GUIDELINES TO MINING DAMS

FOR CDA CALGARY CONFERENCE WORKSHOP ON SLOPE STABILITY

The CDA Mining Dams Committee has prepared this revision to Section 3.5.4.1 of the *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams*. This section deals with the target Factor of Safety for mining dams. The guidance provided in this section is intended for mining dams and supplements the guidance provided by the CDA 2013 Dam Safety Guidelines.

This guidance has been developed over three years, with extensive input and review from CDA members as well from international stakeholders.

The CDA welcomes feedback on our technical publications as a means of ensuring they remain current in describing good industry practice. The feedback can take the form of direct input to the CDA Mining Dams Committee or Dam Safety Committee. For ease of reference, the text that is currently in the Mining Dams Bulletin that was issued in 2014 is attached. Note that Section 3 in the Mining Dams Bulletin dealt with the operation, construction, and transition phases. Section 4 addressed closure. The table numbering in this revision starts at Table 3-4 as Tables 3-1 to 3-3 are previously referenced in Section 3 of the Mining Dams Bulletin.

3.5.4 Geotechnical

3.5.4.1 Targets for Factor of Safety

Overview

This section provides minimum recommended targets for the factor of safety against slope failure of mining dams during the design, construction, operation, and transition phases. It also provides guidance on the strength parameters to be used.

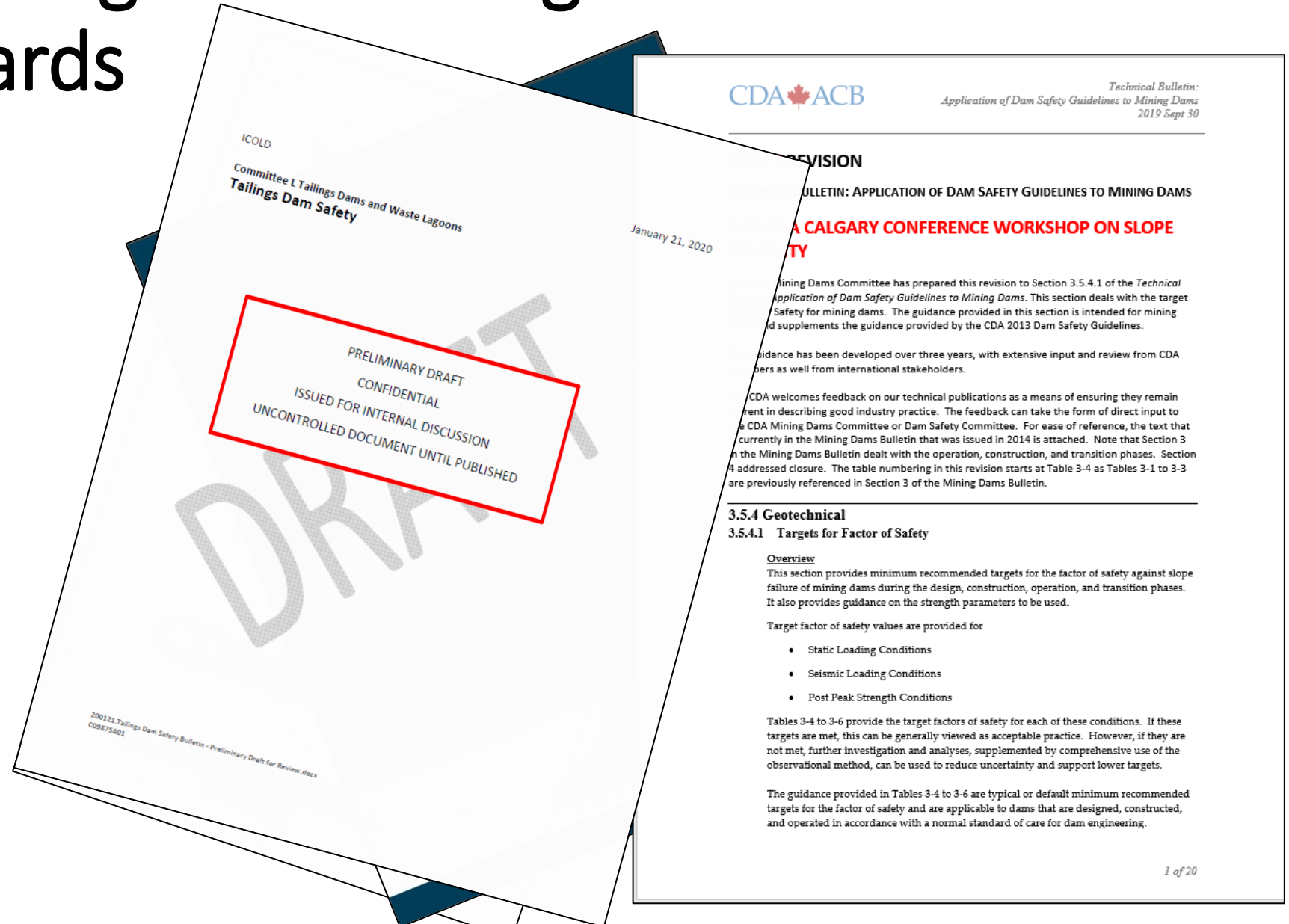
Target factor of safety values are provided for

- Static Loading Conditions
- Seismic Loading Conditions
- Post Peak Strength Conditions

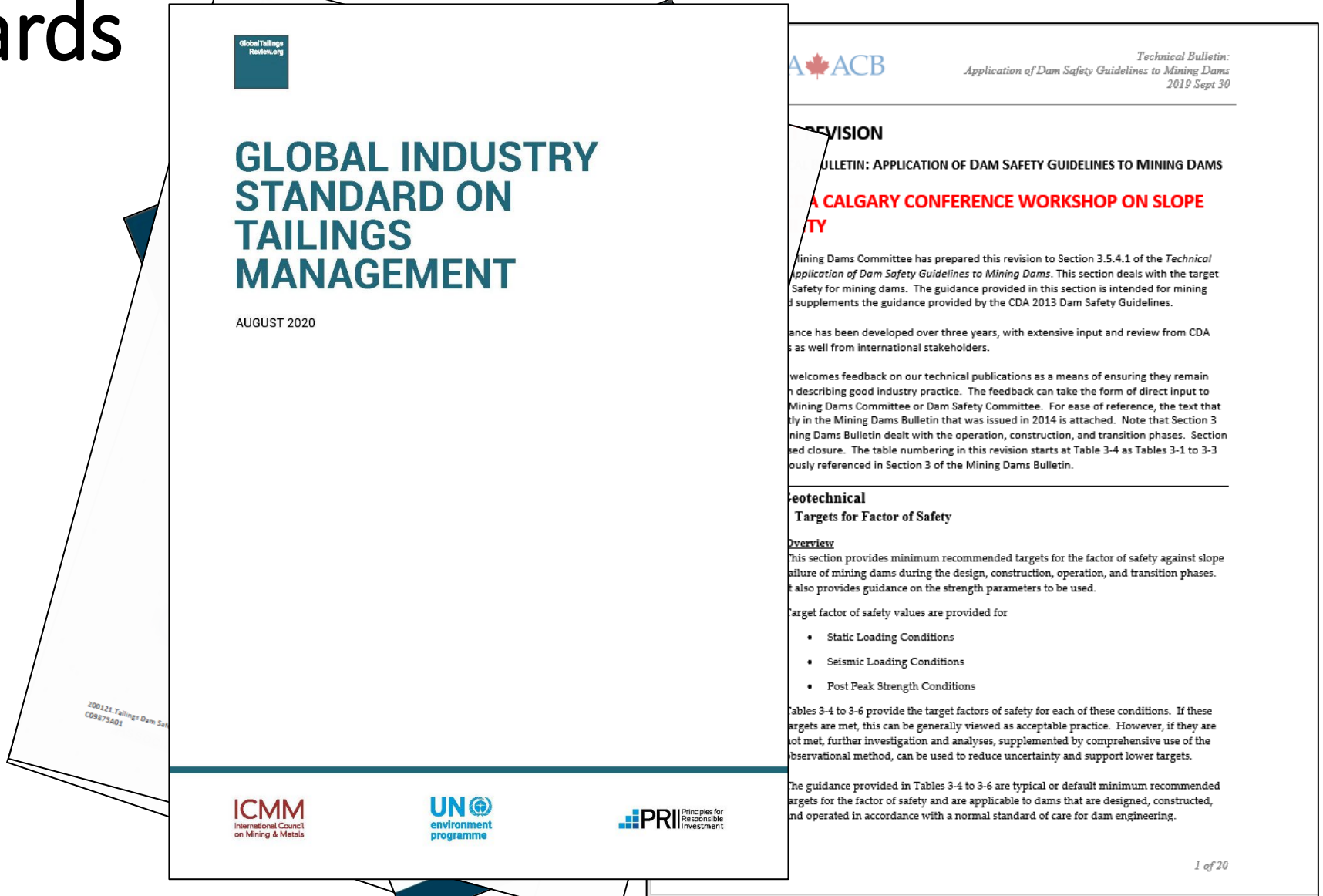
Tables 3-4 to 3-6 provide the target factors of safety for each of these conditions. If these targets are met, this can be generally viewed as acceptable practice. However, if they are not met, further investigation and analyses, supplemented by comprehensive use of the observational method, can be used to reduce uncertainty and support lower targets.

The guidance provided in Tables 3-4 to 3-6 are typical or default minimum recommended targets for the factor of safety and are applicable to dams that are designed, constructed, and operated in accordance with a normal standard of care for dam engineering.

increasing number of guidelines and standards



increasing number of guidelines and standards



USSD Guideline
(forthcoming)

BULLETIN: APPLICATION OF DAM SAFETY GUIDELINES TO MINING DAMS

A CALGARY CONFERENCE WORKSHOP ON SLOPE

The committee has prepared this revision to Section 3.5.4.1 of the *Technical Safety Guidelines to Mining Dams*. This section deals with the target design life. The guidance provided in this section is intended for mining dams. The guidance provided by the CDA 2013 Dam Safety Guidelines.

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For feedback on our technical publications as a means of ensuring they remain leading good industry practice. The feedback can take the form of direct input to the Mining Dams Committee or Dam Safety Committee. For ease of reference, the text that was in the Mining Dams Bulletin that was issued in 2014 is attached. Note that Section 3 of the Mining Dams Bulletin dealt with the operation, construction, and transition phases. Section 4 dealt with closure. The table numbering in this revision starts at Table 3-4 as Tables 3-1 to 3-3 were previously referenced in Section 3 of the Mining Dams Bulletin.

Geotechnical

Targets for Factor of Safety

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target factor of safety values are provided for

- Static Loading Conditions
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increasing number of guidelines and standards

Others

Global Tailings
Review.org

ACB

Technical Bulletin:
Application of Dam Safety Guidelines to Mining Dams
2019 Sept 30

REVISION

BULLETIN: APPLICATION OF DAM SAFETY GUIDELINES TO MINING DAMS

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Technical

Targets for Factor of Safety

This section provides minimum recommended targets for the factor of safety against slope failure for mining dams during the design, construction, operation, and transition phases. The guidance on the strength parameters to be used.

Safety values are provided for

Design Conditions

Construction Conditions

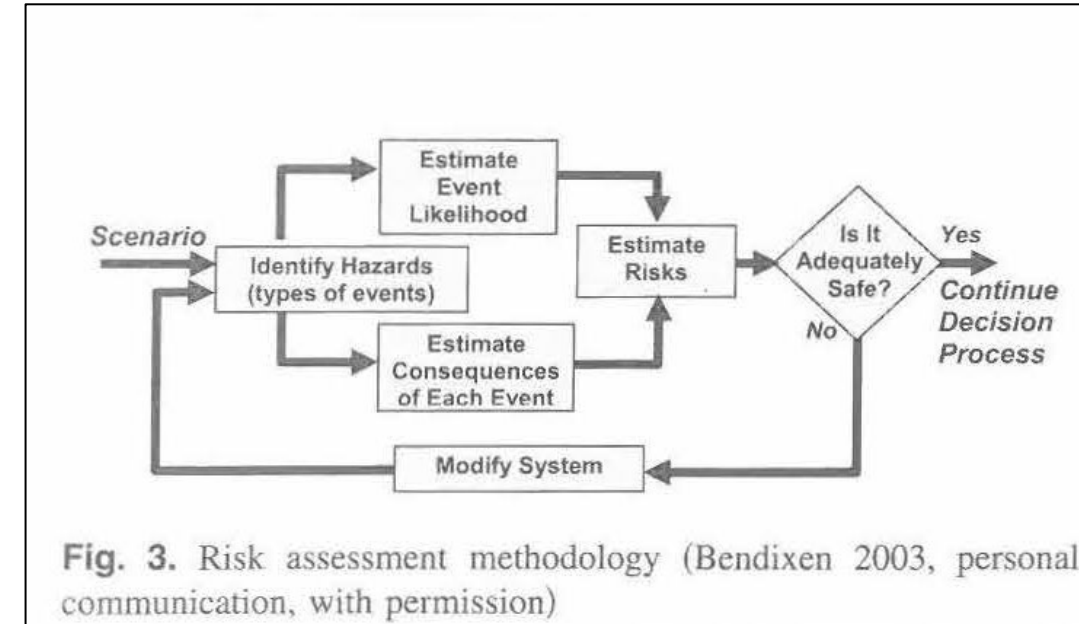
Operation Conditions

Tables 3-4 to 3-6 provide the target factors of safety for each of these conditions. If these targets are met, this can be generally viewed as acceptable practice. However, if they are not met, further investigation and analyses, supplemented by comprehensive use of the observational method, can be used to reduce uncertainty and support lower targets.

The guidance provided in Tables 3-4 to 3-6 are typical or default minimum recommended targets for the factor of safety and are applicable to dams that are designed, constructed, and operated in accordance with a normal standard of care for dam engineering.

evolving standard of care

- undrained, drained, liquefaction
- assume triggering
- higher minimum factors of safety
- more conservative design strengths
- increased use of risk-based design



from Silva et al (2008)

increased use of dam breach analyses



increased use of review boards

Independent Tailings Review Board

A board that provides independent technical review of the design, construction, operation, closure and management of tailings facilities. The independent reviewers are **third-parties who are not, and have not been directly involved** with the design or operation of the particular tailings facility. The **expertise** of the ITRB members shall reflect the range of issues relevant to the facility and its context and the complexity of these issues. In some highly regulated jurisdictions, notably Japan, the role of ITRB is undertaken by the responsible regulatory authorities.

GISTM (2020)

shortage of professional staff

- gray wave
- increased workloads
- recruiting issues
- more educational opportunities

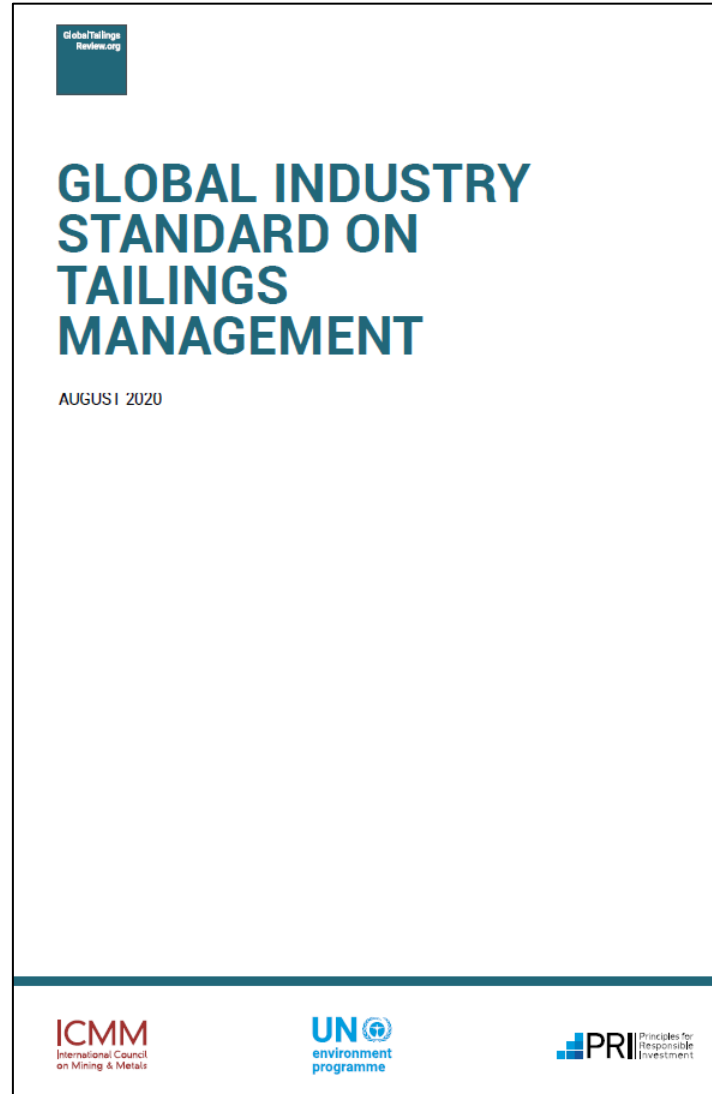


Fundamentals of Tailings Engineering



Proudly offered on behalf of the Tailings and Industrial Waste Engineering (TAILENG) Center and the Tailings Center of Excellence

more stringent regulations



more stringent regulations

Global Tailings
Review.org

PRINCIPLE 1 RESPECT THE RIGHTS OF *PROJECT-AFFECTED PEOPLE* AND
MEANINGFULLY ENGAGE THEM AT ALL PHASES OF THE TAILINGS
FACILITY LIFECYCLE, INCLUDING CLOSURE.

TAILINGS MANAGEMENT

AUGUST 2020

more stringent regulations

Global Tailings
Review.org

PRINCIPLE 1 RESPECT THE RIGHTS OF *PROJECT-AFFECTED PEOPLE* AND
*MEANINGFULLY ENGAGE THEM AT ALL PHASES OF THE TAILINGS
FACILITY LIFECYCLE, INCLUDING CLOSURE.*

PRINCIPLE 3 USE ALL ELEMENTS OF THE *KNOWLEDGE BASE - SOCIAL,
ENVIRONMENTAL, LOCAL ECONOMIC AND TECHNICAL -*
*TO INFORM DECISIONS THROUGHOUT THE TAILINGS FACILITY
LIFECYCLE, INCLUDING CLOSURE.*

more stringent regulations

Global Tailings
Review.org

PRINCIPLE 1 RESPECT THE RIGHTS OF *PROJECT-AFFECTED PEOPLE* AND *MEANINGFULLY ENGAGE THEM AT ALL PHASES OF THE TAILINGS FACILITY LIFECYCLE, INCLUDING CLOSURE.*

PRINCIPLE 3 USE ALL ELEMENTS OF THE *KNOWLEDGE BASE - SOCIAL, ENVIRONMENTAL, LOCAL ECONOMIC AND TECHNICAL - TO INFORM DECISIONS THROUGHOUT THE TAILINGS FACILITY LIFECYCLE, INCLUDING CLOSURE.*

PRINCIPLE 10 ESTABLISH AND IMPLEMENT LEVELS OF REVIEW AS PART OF A STRONG QUALITY AND RISK MANAGEMENT SYSTEM FOR ALL PHASES OF THE *TAILINGS FACILITY LIFECYCLE, INCLUDING CLOSURE.*

more stringent regulations

Global Tailings
Review.org

PRINCIPLE 1 RESPECT THE RIGHTS OF *PROJECT-AFFECTED PEOPLE* AND *MEANINGFULLY ENGAGE THEM AT ALL PHASES OF THE TAILINGS FACILITY LIFECYCLE, INCLUDING CLOSURE.*

PRINCIPLE 3 USE ALL ELEMENTS OF THE *KNOWLEDGE BASE - SOCIAL, ENVIRONMENTAL, LOCAL ECONOMIC AND TECHNICAL -* TO INFORM DECISIONS THROUGHOUT THE *TAILINGS FACILITY LIFECYCLE, INCLUDING CLOSURE.*

PRINCIPLE 10 ESTABLISH AND IMPLEMENT LEVELS OF REVIEW AS PART OF A STRONG QUALITY AND RISK MANAGEMENT SYSTEM FOR ALL PHASES OF THE *TAILINGS FACILITY LIFECYCLE, INCLUDING CLOSURE.*

PRINCIPLE 15 PUBLICLY DISCLOSE AND PROVIDE ACCESS TO INFORMATION ABOUT THE *TAILINGS FACILITY* TO SUPPORT PUBLIC ACCOUNTABILITY.

closing

- the overwhelming majority of TSFs are safe and will not experience dam safety issues
- however, recent failures have resulted in a step change within the industry
- hard-learned lessons offer the opportunity for improvement
- the industry has responded positively and is better for it
- challenges remain, but the industry is up for it

thank you



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resourceful. naturally.

