

# What Could Tailings Facility Engineering Look Like in 2030? Version 6.0



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**17th PAN-AMERICAN CONFERENCE**  
ON SOIL MECHANICS AND GEOTECHNICAL ENGINEERING

2<sup>nd</sup> LATIN-AMERICAN REGIONAL  
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**Annika Bjelkevik, TCS, Sweden**

**Andrew Witte, KCB, Canada**

# ▶ ISSMGE TC221


International Society for Soil Mechanics and Geotechnical Engineering

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TC221 Tailing and Mine Wastes

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Tailing and Mine Wastes

- Thanks to:
  - Ramon Verdugo, CMGI, Chair of TC221
  - Luis Valenzuela, Geotechnical Consultants, Chair of the Scientific Committee

# ► Tailings Facility Engineering

- Tailings milling and processing
- Design of tailings storage facilities
- Closure design
- Geotechnical engineering
- Hydrogeological engineering
- Hydrotechnical engineering
- Geology
- Geochemistry
- Environmental protection
- Construction
- Operations
- Surveillance
- Risk Assessment
- Governance

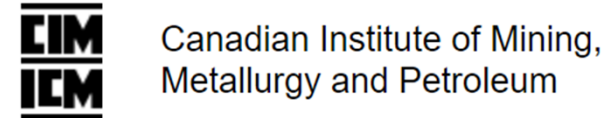
- Engineering and scientific studies
- Field work (drilling, construction)
- Lab analyses (testing and interpretation)
- Modelling (simple to advanced)

## ► Future Mining

- ICOLD: world-wide registry with over 24,000 TSFs (Rana et al, 2024)
- Mining expected to increase by about 3%/year
- Grades of ore bodies are reducing
- Leads to more tailings
- Repurposing old facilities



# ► Organizations Supporting T.F.E.



CANBREACH

Universities, technical associations, etc.

## ► Why 2030?

- Why not 2040 or 2050?
- “Next 6 years will go by in the blink of an eye”
- Reflect on some of what has happened in the past 6 years
- Start with guidance documents

# ▶ Guides Supporting Tailings Facility Engineering

2010

2011

2012

2013

2014

2015

2016

2017

**2011:** ICOLD Bulletin 139:  
Improving Tailings Dam  
Safety

**2012:** ANCOLD Guidelines on  
Tailings Dams

**2013:** ICOLD Bulletin 153:  
Sustainable Design and Post-  
Closure Performance of Tailings  
Dams

**2014:** CDA  
Mining Dams  
Bulletin

**2014:** De-Licensing of  
Oilsands Tailings Dams

**MAC:** Tailings Management  
Guides, OMS Guides

ICOLD – International Commission on Large Dams

ANCOLD – Australia National Commission on Large Dams

CDA – Canadian Dam Association

MAC - Mining Association of Canada

## ▶ Guides (cont'd)

2018

2019

2020

2021

2022

2023

2024

**2018:** Dr. Morgenstern's DiMello lecture on Performance Based Risk Informed Design

**2019:** ICMM Integrated Mine Closure Good Practice Guide

**2020:** Global Industry Standard on Tailings Management

**2021:** ICMM Good Practice Guide on Tailings Management

**2021:** CDA Tailings Dam Breach Guidance

**2021:** Establishment of Landform Design Institute

**2021:** Establishment of CDA/USSD Joint Working Group on EOR

**2022:** Tailings Management Handbook

**2022:** ICOLD Bulletin 194: Tailings Dam Safety Guideline

**2022:** Assessment Tool for Landforms in Oilsands

**MAC:** Tailings Management Guides, OMS Guides,



## ► Why 2030?

- Reflect on other activities in the past 6 years:

Topic	2018	2024
Engineer of Record	Significant trepidation	Young engineers are viewing this as a viable career path
Surveillance	Some automation	Extensive automation and innovative technologies
Artificial Intelligence	Not prevalent	Playing a bigger role

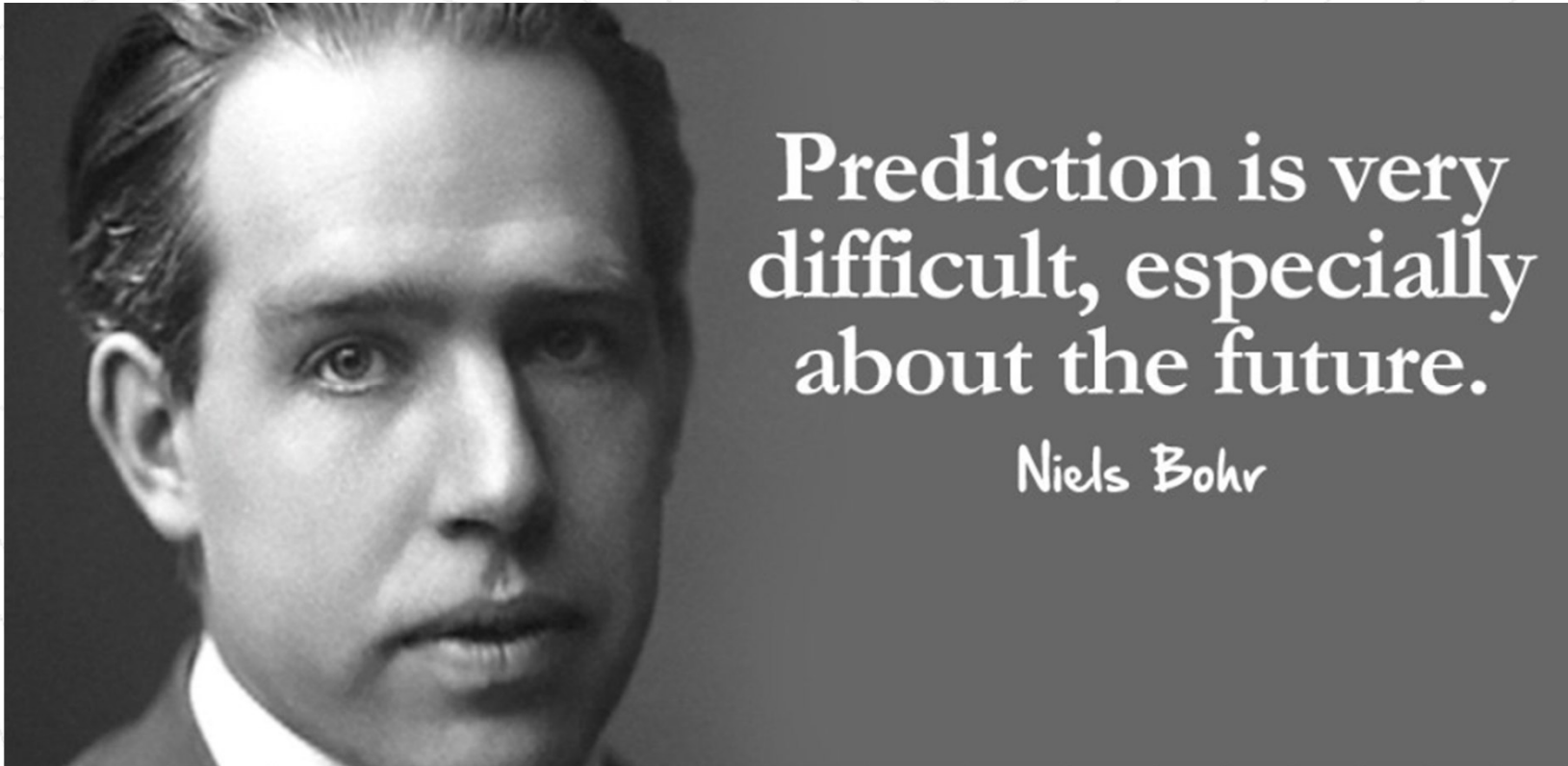
- Opportunity to maintain the momentum that has been built
- Opportunity for more than “continuous improvement”
- We believe the next 6 years could see continued significant advancements

## ► Context

- Positive:
  - Many risk reduction initiatives underway
  - Moving in a good direction
  - Reducing likelihood of catastrophic failures
  - Owners and Consultants have created safe environments for young engineers
  - Training programs
  - Gain in computing power
  - Artificial Intelligence
  - TSF Registry (>24,000 TSFs catalogued)
- Challenges:
  - Water scarcity
  - Investors and insurance companies are paying a great deal of attention
  - Significant demand for EORs, RTFEs, ITRBs
  - Lack of engineers
  - Loss of senior engineers
  - Need to attract and retain talent
  - Dealing with classic upstream facilities

How do we get ahead of some of these challenges?

## ► Visioning to 2030



# ► What Could Tailings Facility Engineering Look Like in 2030?

1. Technical:
  - a) Tailings technology and deposition strategies
  - b) Closure strategies
  - c) Characterization of tailings and foundation soils
  - d) Design
  - e) Surveillance
2. Competency and Capacity:
  - a) Guidance documents
  - b) Training and development of Tailings Facility Engineers
  - c) Regulatory competency and capacity
- Governance is a key item that is also evolving, but beyond our scope

## ▶ Intended Audience

- Owners and Operators
- Consultants
- Academia
- Suppliers
- Regulators
  
- Engineers who may be interested in tailings facility engineering, but would like to know where we are headed
- Geotechnical, geological, hydrogeological, and civil engineers



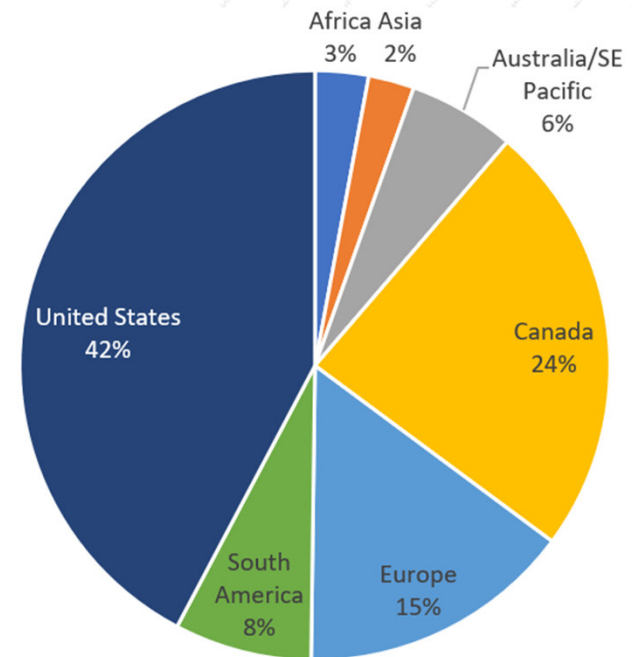
- Young engineers

## ▶ Papers and Presentations

Version	Forum	Location	Deliverable	Date (2024)	Presenter
1.0	Calgary Geotechnical Society	Calgary	Presentation	May 14	Andy
2.0	Edmonton Geotechnical Society	Edmonton	Presentation	May 16	Andy
3.0	Mining Society of Nova Scotia	Nova Scotia	Presentation	July	Andy
4.0	ICOLD	India	Presentation and paper	September	Annika
5.0	Tailings and Mine Waste	Denver	Presentation and paper	November	Andrew
6.0	International Society of Soil Mechanics and Geotechnical Engineering	Chile	Presentation and paper	November	Andy

## ▶ Questionnaire to Colleagues/Leaders

- To support development of the presentations and papers
- Issued to over 240 colleagues around the world
- Over 60 responses
- Lots is happening, this presentation provides some of the highlights
- South America:
  - Eduardo Marques, Brazil
  - João Pimenta Freire Neto, Brazil
  - Mauro Pio dos Santos Junior, Brazil
  - Emmanuel Pornillos, Peru
  - Fernando Schnaid, Brazil
  - Luis Valenzuela, Chile



# ▶ Contributors to Questionnaire

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Krzysztof	Wrzosek	ICOLD	Poland



# ▶ Available to Public

- Presentations and questionnaire results available on publicly accessible drive: <https://klohn.com/technical-papers/what-could-tailings-facility-engineering-look-like-in-2030/>

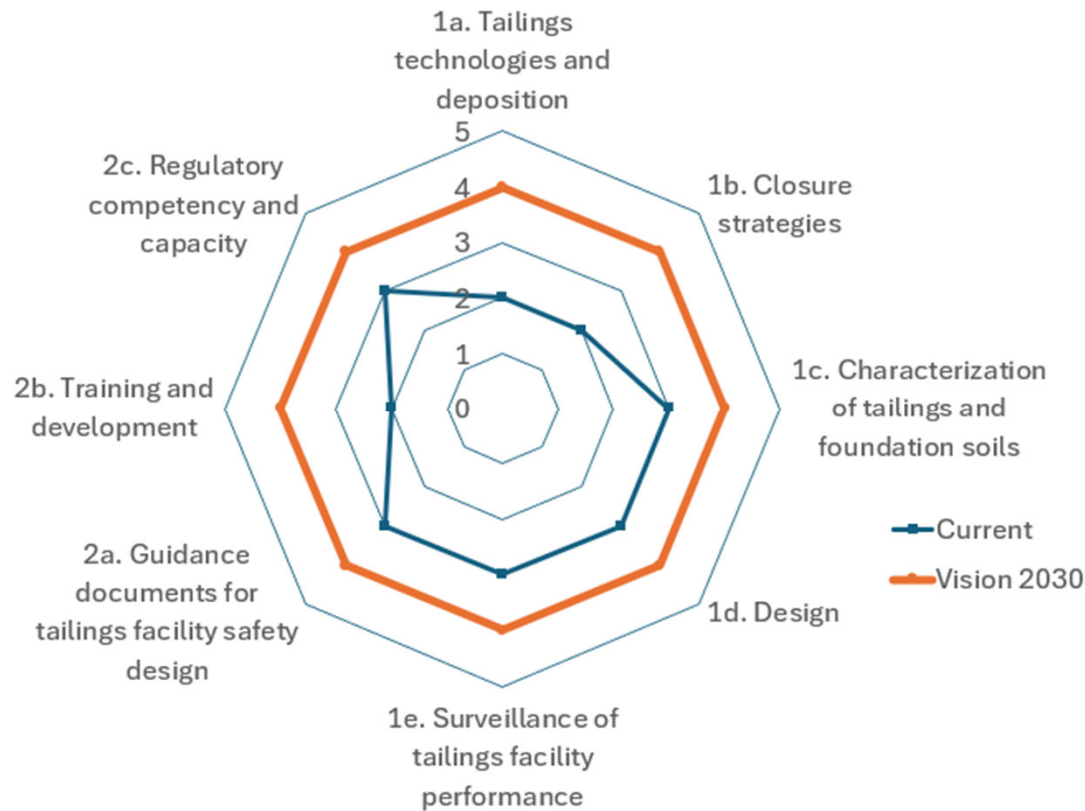


## ▶ Feedback Welcome

- Prepare an addendum to the paper.



# ► Estimated situation for each topic



- 0** = not implemented / used / known
- 1** = implemented in research / regarded as future (pilot test) / known by few
- 2** = implemented in a few operations / used in a few places / known by few but regarded as an option
- 3** = implemented in most operations / used in most places / known by many
- 4** = implemented in many operations / used in many places / known by most
- 5** = implemented in “all” operations / best possible use / fully known

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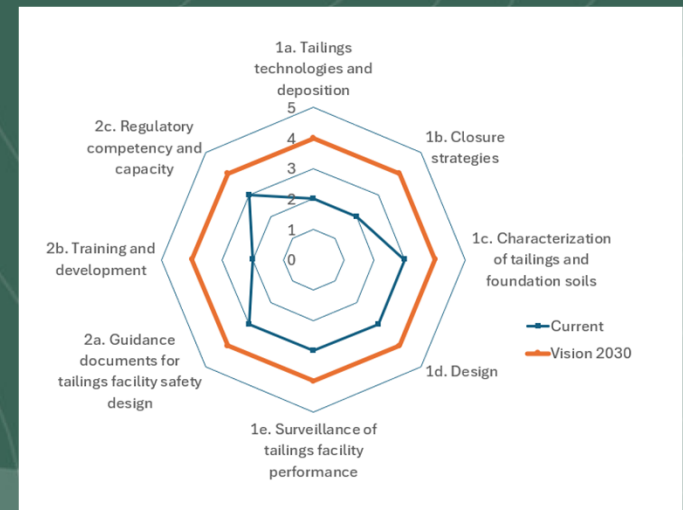
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## 2. Competency and Capacity:

- a) Guidance documents
- b) Training and development of Tailings Facility Engineers**
- c) Regulatory competency and capacity

# Part 2b – Training and Development



## ▶ 2b – Tailings Management Professional

- Establish the discipline of Tailings Management Professional
- Tailings management includes the design, construction operation, and closure of systems that are used to produce tailings and the facilities that are constructed to store tailings
- Tailings structures include:
  - Conventional slurry, thickened, paste, filtered tailings stacks, etc.
  - Co-disposal with waste rock
  - Sludge and sediment containment facilities from process, water treatment plants, or runoff.

## ▶ 2b – Tailings Management Prof. (cont'd)

- Tailings milling and processing
- Design of tailings storage facilities
- Closure design
- Geotechnical engineering
- Hydrogeological engineering
- Hydrotechnical engineering
- Geology
- Geochemistry
- Environmental protection
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- Operations
- Surveillance
- Risk Assessment
- Governance

## ▶ 2b –Training and Dev. - Path Forward

Vision for 2030	Action	Organizations	Role
Tailings Management Professional	Develop scope for this discipline and embrace usage	ICOLD	Lead development, work with ICMM, SME, CDA, ANCOLD, universities, etc.
Decision w.r.t. certification of Tailings Management Professional	Study this issue and land on a decision	ICOLD	Form working group to explore this issue. Work with ICMM, SME, CDA, ANCOLD, universities, etc.
Coordinated training	Develop Tailings Training Portal that reflects available training in the world. Use the Portal to support developing a coordinated training program.	SME	Host for the portal, supported by several organizations
Tailings cohorts in post graduate programs	Develop Masters-level program focused on training engineers to enter the tailings profession	Colorado State University	Lead development of this initiative, supported by other universities



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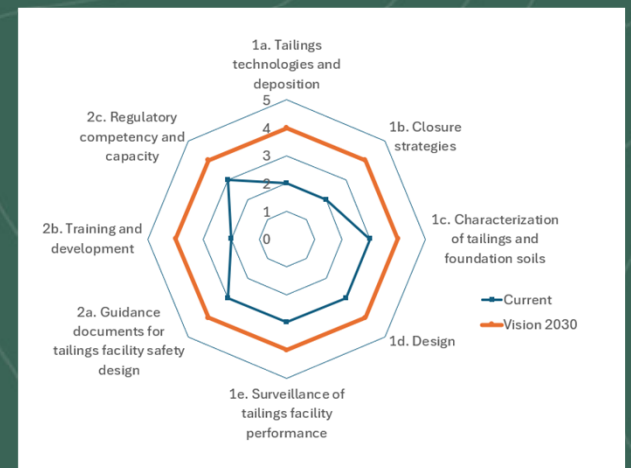
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# Part 1 – Technical Topics



## ► 1a - Tailings Technology – 2030?

- Conventional/slurried tailings:
  - Still will be the majority of tailings systems with focus on centerline and downstream dams
  - There will not be new TSFs built using the classical approach for upstream dams (liquefiable elements in the structural shell)
  - High degree of confidence in slurry tailings facilities
- Filtered tailings will play a larger role



## ▶ 1a - Tailings Technology - Path Forward

Vision for 2030	Action	Organizations	Role
Guidance on Filtered Tailings	Comprehensive, publicly available guidance document that addresses process and geotechnical aspects, but also, possibly enhanced financial models	Filtered tailings industry and SME	To lead the development of the guidance. Supported by ICOLD and other organizations.
MAA that considers the whole mine, not just the tailings. Includes the mining plan, water restrictions, closure, etc.	Work with mining companies and MAC/ICMM to promote this concept. Also, develop financial models that can support better closure decisions.	Lead to be determined	To be determined
Co-disposal of tailings and waste rock more prominent	To develop		
High level of confidence in safety of conventional/slurried tailings systems	Continue training and development	All	Continue solid engineering

## ► 1b – Closure Strategies – 2030?

- Consensus between all parties of an appropriate definition of Safe closure/ Responsible closure
- Defined and standardized design criteria for closure, incl. transfer of ownership
- Less water in the tailings and impoundments
- Financial models that benefit good practices
- Long-term monitoring with remote methods and AI
- Established the role of reclamation designer of record (RDR) working in parallel with EOR.

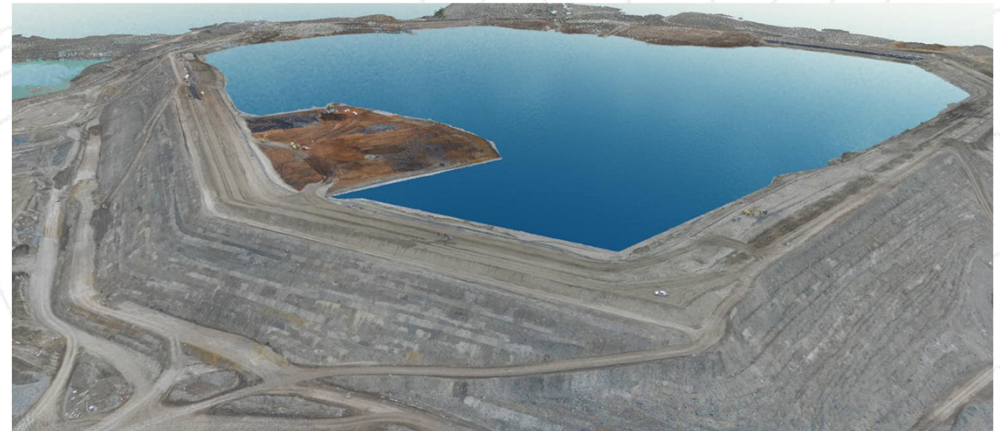


## ▶ 1b – Closure Strategies – Path Forward

Vision for 2030	Action	Organizations	Role
Tailings Closure Handbook	<p>“Begin with the end in mind. Closure should not be an afterthought.</p> <ul style="list-style-type: none"> <li>- closure design considerations/ criteria</li> <li>- safe/responsible closure</li> <li>- landform design</li> <li>- governance</li> <li>- relinquishment</li> <li>- cost estimating / bonding”</li> </ul>	SME	SME to lead development of handbook. The book editors are engaging with other organizations (e.g., USSD, CDA).
Risk Informed Closure Design	Develop guidance on “responsible” closure.	CDA	CDA to lead with input from ICOLD, USSD, SME, ICMM, etc.
No water covers required for geochemistry reasons	<p>Desulphurization of tailings in the mill.</p> <p>Dry covers.</p> <p>Enhanced financial models.</p>	MAC or ICMM?	ICOLD will monitor

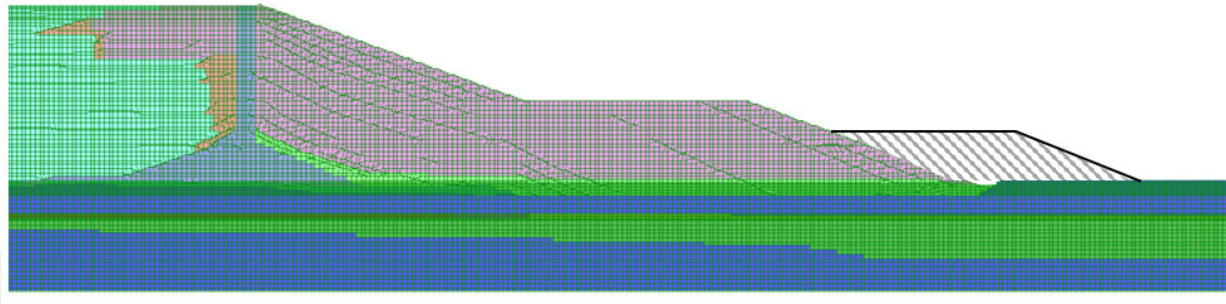
## ► 1c – Char. Tailings and Found. Soils – 2030?

- Use of nuclear magnetic resonance well logging and other in-situ technologies on CPTs for water content estimation
- Improved ability to estimate in-situ void ratio and state parameter
- Improved characterization of liquefaction potential and post liquefaction strength
- Initiatives underway by academia, industry, and suppliers



## ► 1d – Design – 2030?

- Performance Based Design for Slope Stability Assessment:
  - PB design integrates advanced computer modelling with actual performance to reduce uncertainty and conservatisms in design
  - From Dr. Morgenstern: “Further recognition of the value of Performance Based Design and significantly greater prominence in its use.”
  - Integration of complementary roles of PBD and classical approaches
  - Fully coupled deformation and seepage models
  - Regulatory capacity will still be a limitation to implementation
- Dam breach analysis that can be relied upon.

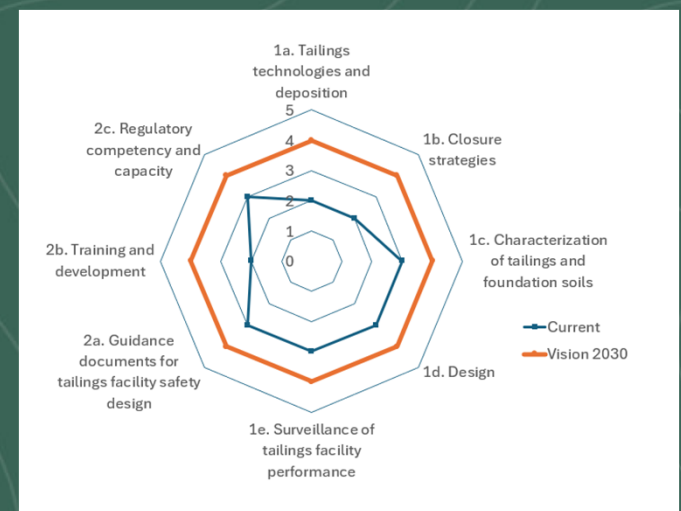




## ► 1d - Design – Path Forward

Vision for 2030	Action	Organizations	Role
Greater use of Performance Based Design	Education, case studies	ICMM, CDA, and industry	ICMM and CDA – training Industry – case studies on PB design
Reduced uncertainty for dam breach analyses	Research to improve models and characterization and enhance guidance	CANBREACH CDA	CANBREACH – research CDA - guidance

# Part 2 – Competency and Capacity



## ▶ 2a – Guidance Documents

- Some said: “We have enough guidance documents, use what we have!”
- Guidelines in review/being updated:
  - MAC
  - CDA
  - USSD (FEMA)
  - CDA/USSD EOR
  - Landform Design Guidance
  - ICOLD Bulletin 194:
    - hydrogeology and hydrology, undrained stability analyses, brittleness stability, spillways, characterization
  - Others

## ► Key Initiatives Supporting the 2030 Vision

- Tailings Management Professional
- Tailings Training portal
- Site characterization
- Performance based design
- Improvements to dam breach analyses
- Modified financial models
- Key guidance documents
  
- Fraction of the initiatives that are happening in the world
- Many other good initiatives are underway, pleased to include in our addendum
- Let's maintain the momentum and go beyond just "continuous improvement"!

► **Being a Tailings Management Professional is and will be very interesting!**



Annika Bjelkevik,  
TCS Sweden



Andrew Witte,  
KCB Vancouver



Andy Small,  
KCB Fredericton

# ▶ Thank you - Feedback welcome

- Prepare an addendum to the paper.



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