Coal Tailings Dams: Where to from here?

Presentation to:

Vancouver Coal Society

Sean Ennis
Vice President, Mining

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NORWEST
CORPORATION

Presentation Overview

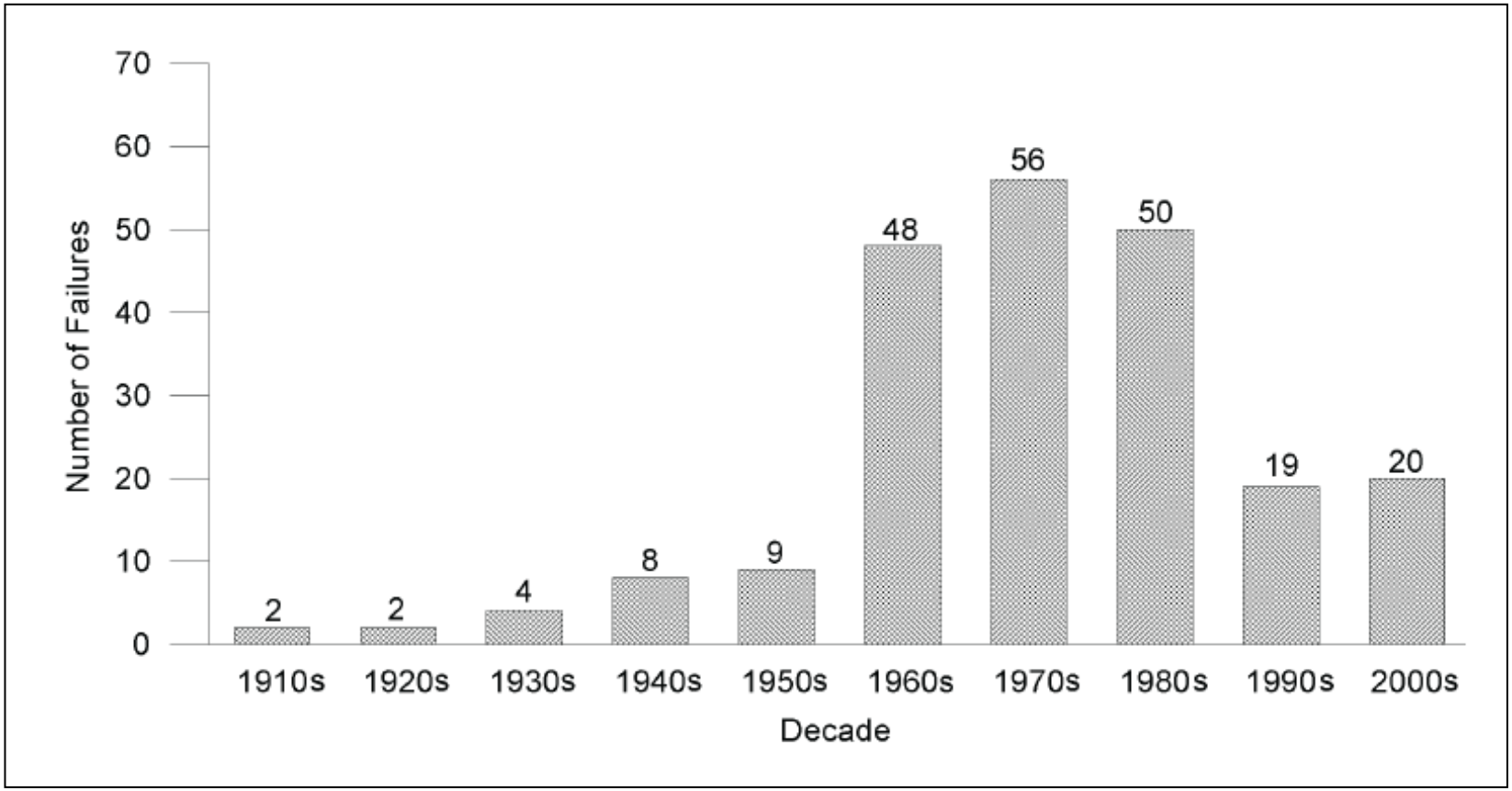
- In the news
- Understanding the level of risk
- Regulators and stakeholders
- A time of transition?
- Current practices
- Evaluating options for new projects
- Where to from here?

Coal tailings in the News!

- Obed Mountain Mine – Alberta, October 2013
- Basin Coal Mine – British Columbia, August 2013
- Dan River Coal Plant – North Carolina, February 2014

Understanding the level of risk

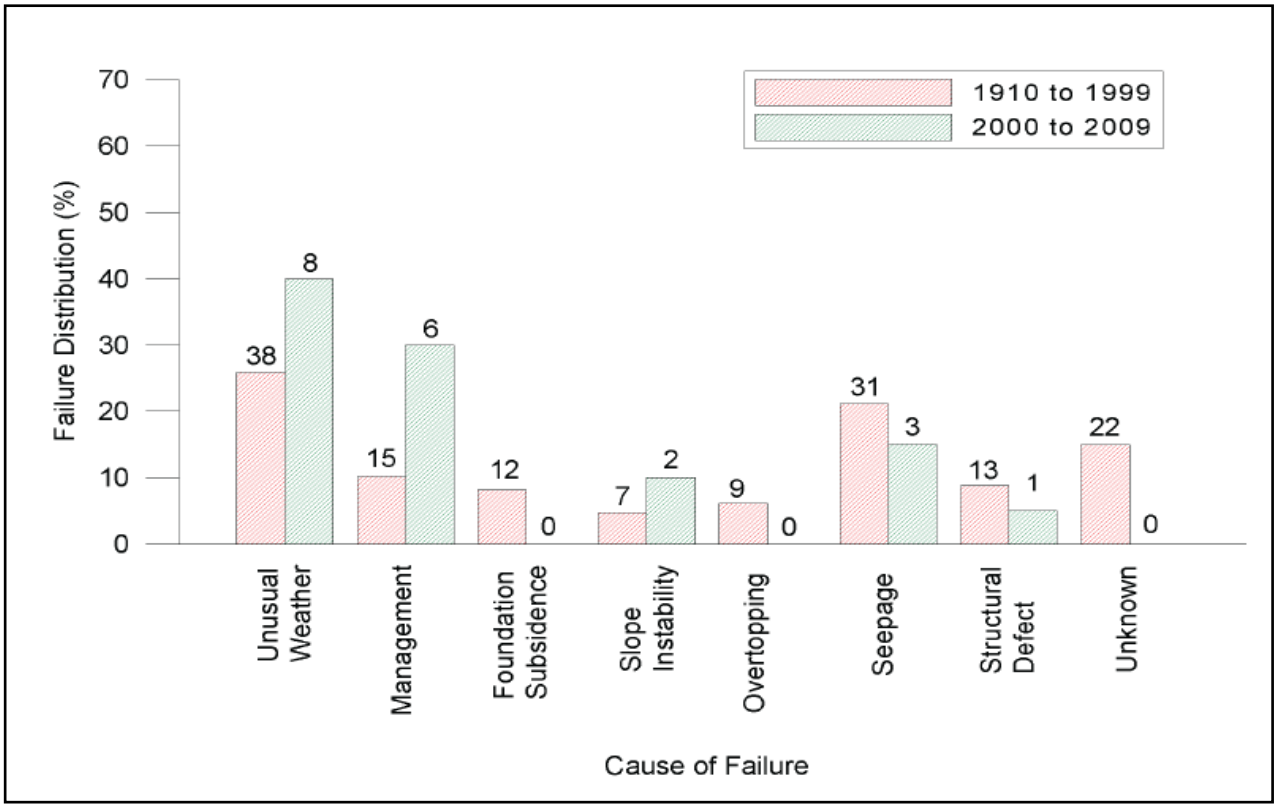
Number of tailings dam failures by decade



Data from Azam, 2010. "Tailings dam failures: A review of the last 100 years." Geotechnical News

Understanding the level of risk - 2

- Tailings dams fail at a rate approximately 100 times higher than conventional water dams (1.2% versus 0.01%). Why?



Data from Azam, 2010. "Tailings dam failures: A review of the last 100 years." Geotechnical News

Regulators and Stakeholders

- Lower risk tolerance
- Higher awareness of environmental effects
- Increased level of technical assurance related to operations and closure
- Concern over geochemical / trace element release and contamination
- Restrictions on footprint and areas acceptable for construction (NIMBY & BANANA)

Regulators and Stakeholders - 2

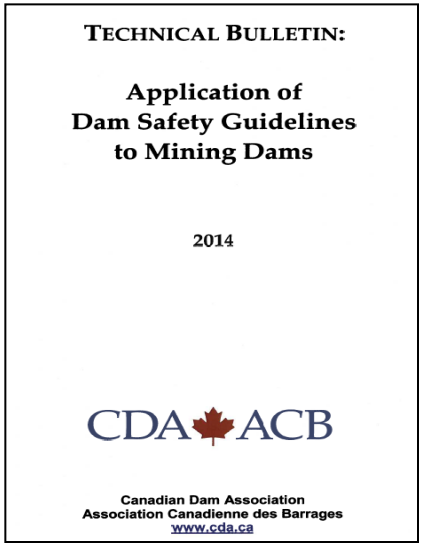
Issues of focus for regulators:

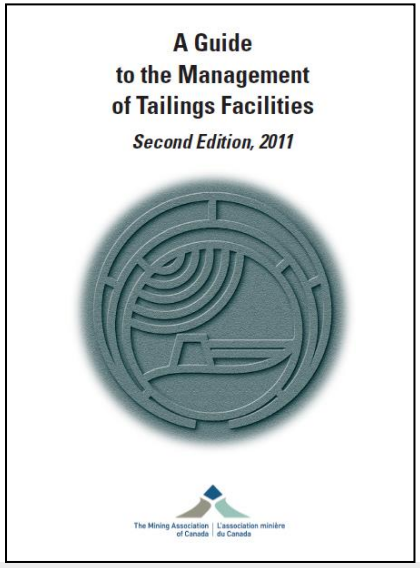
- Downstream consequences (people, environment)
- Operational practices/controls (OMS, ERP)
- Environmental effects (seepage, leachates, dusting, direct contact with wildlife/waterfowl)
- Viability of reclamation and closure plan
- Long-term liability

Movement to lower risk facilities (ref. EPA Dec. 2014)

Current Practice – Design and Management Guidance

- Provincial dam design regulations/guidelines
- Canadian Dam Association – *new 2014 guidelines*
- Mining Association of Canada – multiple reports
- ICOLD guidelines / standards
- United States and Others– MSHA, OSM, State, SMCRA, EPA

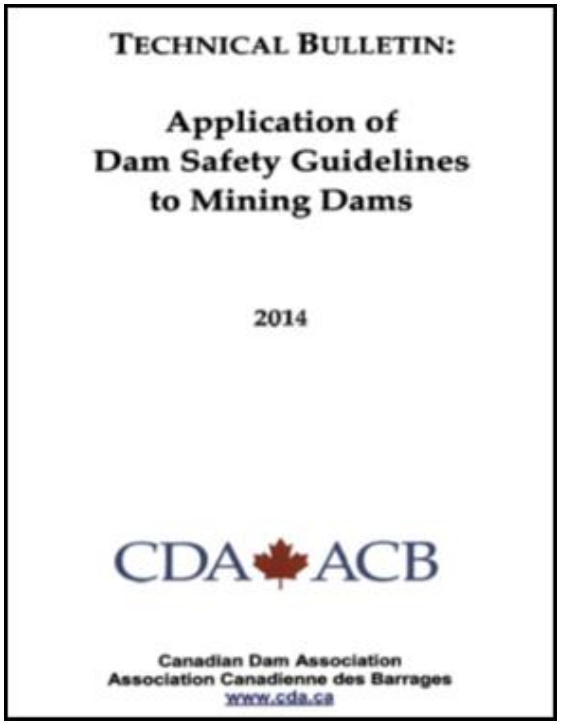




Dam Design requirements (CDA 2014)

Dam Classification	Annual Exceedance Probability – Floods (note 1)
Low	1/100
Significant	Between 1/100 and 1/1,000 (note 2)
High	1/3 Between 1/1,000 and PMF (note 3)
Very High	2/3 Between 1/1,000 and PMF (note 3)
Extreme	PMF (note 3)

Dam Classification	Annual Exceedance Probability – Earthquakes (note 1)
Low	1/100 AEP
Significant	Between 1/100 and 1/1,000
High	1/2,475 (note 2)
Very High	1/2 Between 1/2,475 (note 2) and 1/10,000 or MCE (note 3)
Extreme	1/10,000 or MCE (note 3)



A time of transition?

Operations in NE BC started since 2000:

- **Willow Creek Mine** – Filtered tailings product with stand-alone stockpile
- **Wolverine Mine** – Conventional tailings pond with CCR dyke
- **Brule Mine** – ROM product (washed at Willow Creek)
- **Trend Mine** – Filtered tailings product with co-disposal in waste rock dumps

Current Practice – Conventional Coal Tailings Dams

- Typically two waste streams – coarse coal rejects (CCR) and “fines”
- Sequence of development - construct starter dyke of compacted fill and then use CCR for successive dyke raises
- Tailings impoundments not typically lined
- Discharge spigots onto tailings beach from dyke crest
- Tailings pond is a source of make-up water for the process plant
- Reclamation plan relies on natural drainage/consolidation of tailings followed by capping. Dyke and impoundment reconfigured to prevent containment of water.

Current Practice – Construction and Operations

Current Practice – Closure of a tailings impoundment

Coal tailings beach 10 years after operations ceased (photo from 2013)

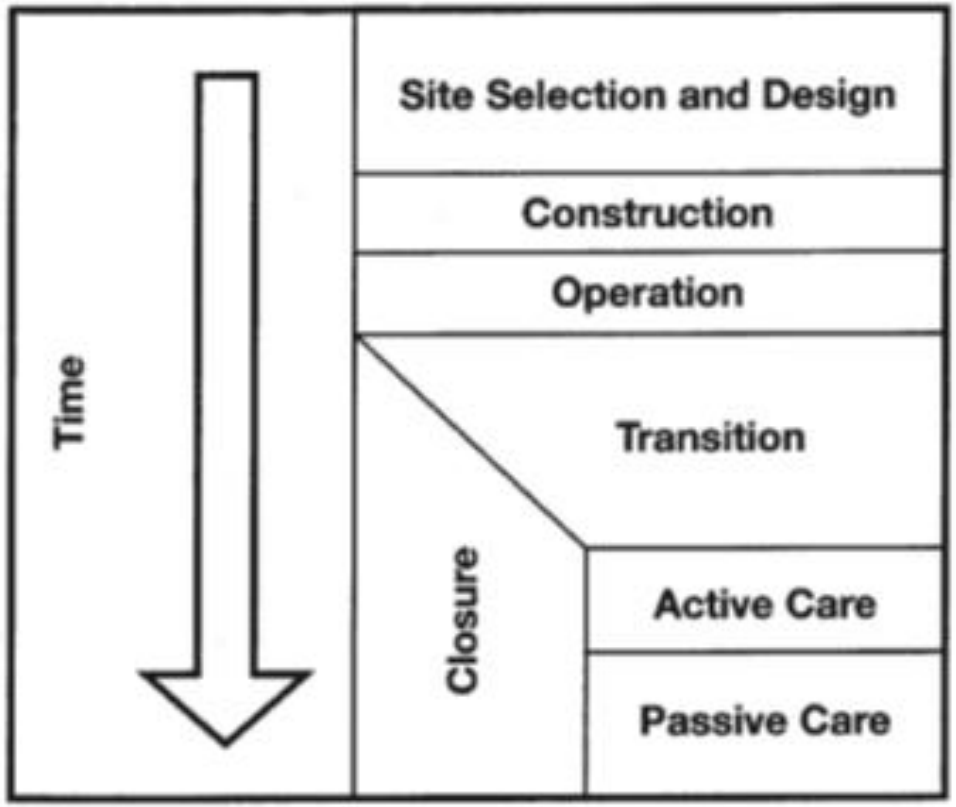
Evaluating Options for New Projects - 1

Coal process wastes – management options:

- Conventional slurried tailings
- Thickened / paste tailings
- Filtered tailings
- Co-disposal / co-mingling of wastes

Evaluating Options - Life cycle

Phases in the life of a mining dam



This is a MULTI-DISCIPLINARY effort.

A similar life cycle can be applied to other tailings storage methods.

Evaluating Options for New Projects

Tailings options:

- Slurried tailings: 20 - 30% solids
- Thickened / paste tailings: 40 – 60% solids
- Filtered tailings: >70% solids
- Co-disposal / co-mingling of wastes: varies on blending and processes selected

Non-slurried options seek to reduce water volumes and/or utilize void space within a waste matrix:

Seeking more efficient use of volume and a less mobile final deposit.

Evaluating Options – practical considerations 1

- Capital versus operating costs:
  - Don’t underestimate construction costs related to starter dykes.
  - Evaluate the full life cycle.
  - Take advantage of containment with lower (or no) downstream consequences.

Evaluating Options – practical considerations 2

- What is the tailings product?:
  - Get representative samples of expected process waste products early.
  - There are NO dry tailings!
  - Blending wastes may make you worse off then keeping them separate.

Evaluating Options – “Dry” does not mean dry

Evaluating Options – practical considerations 3

- Operational considerations:
  - Every system/process has off-spec periods – what is your back-up?
  - Will the storage location change over time?
  - Will the management or method change over the mine life?

Evaluating Options – recent example of cost comparison

- Evaluation over start-up and operating life of a project:

Tailings Disposal Trade Off Study Summary					
ROM Coal Tonnes per Year	3.7	million tonnes			
Total ROM Coal Reserves	55.8	million tonnes			
Fine Filtered Tailings	4.3	million tonnes			
Life of Mine	15	Years			
Options		**LOM Operating Costs**	**LOM Capital Costs**	**Total LOM Costs**	**NPC**
					10%
Option A. Plate Press Filtered Tailings and Blended Disposal		$15,460,000	$6,371,000	$21,831,000	$13,678,000
B. Tailings Impoundment		$1,240,000	$22,218,000	$23,458,000	$14,712,000
C. Belt Press Filtered Tailings and Blended Disposal		$18,920,000	$4,314,000	$23,234,000	$13,080,000

Where to from here?

- We have the understanding and a body of knowledge of how to design and manage tailings facilities but as an industry the failure rate is still too high.

We stand to lose a useful storage option without improvement.

Where to from here?

- Regulators, stakeholders and investors will to continue to push us towards lower risk storage options.

Seeking lower risk to people, the environment and enterprise value.

Where to from here?

- An objective evaluation of tailings storage options with diligent investigation and testing will provide insight into what is the “best defendable” option for the project.

Permitting, social license and investment will require this.

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- Regulators, stakeholders and investors will to continue to push us towards lower risk storage options. *Lower risk to people, the environment and enterprise value*.
- An objective evaluation of tailings storage options with diligent investigation and testing will provide insight into what is the "best defendable" option for the project. *Permitting, social license and investment will require this*.