MEND
Study of Tailings Management Technologies

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1. Introduction
   - Study Objectives
   - Methodology
   - Spoiler Alert: Key Conclusion

2. Tailings Management Strategy Considerations
   - Tailings Properties
   - Site Conditions
   - Dewatering Technologies and Facility Types

3. Case Histories
   - Canadian Projects using Dewatering Technologies
   - Select Case Studies

4. Conclusions
Study Objectives

• Identify state-of-practice of tailings dewatering technologies (e.g. thickened, paste and filtered tailings) and their associated facility types in Canada.

• Assess strengths, limitations, and physical and geochemical risks across the life-cycle of a tailings facilities for the technologies and compare them to those of conventional slurry.

• Identify knowledge gaps and make recommendations for further work.
Every project and tailings facility has a unique combination of site conditions, tailings characteristics, available resources, social and regulatory environment, and countless other factors that must be considered throughout the project life-cycle. Many of the observations and conclusions in this report are generalized and there are undoubtedly exceptions to some of these statements depending on project-specific conditions.

This study does not delve into comparing the different types of containment structures and material types for conventional facilities (e.g. upstream, downstream, centreline, cycloned sand, waste rock). Containment dam design is an important part of risk management associated with tailings facilities that should also be considered during selection of a tailings management strategy.

1) Conclusions are generalized, undoubtedly there will be exceptions.

2) The scope of this study does not cover everything, in particular: dam design and closure design that is unrelated to tailings dewatering.
Step 1 - Identify the current state-of-practice and projects using dewatering technologies in Canada through literature review, database research, and a questionnaire sent to all Canadian mine sites.

Step 2 – Compare dewatering technologies and facility types to conventional means of tailings management.

Step 3 – Identify lessons learned and knowledge gaps.
NO ONE-SIZE-FITS-ALL Technology for Tailings Management
NO ONE-SIZE-FITS-ALL Technology for Tailings Management

TAILINGS MANAGEMENT = RISK MANAGEMENT
Presentation Objectives

• Brief overview of the study
• Present key learnings through case histories

Image Reference: Paterson & Cooke 2017
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Tailings Management Strategy Considerations

- Tailings characteristics (physical and chemical) and scale of operation
- Site conditions (physical, environmental, social, climatic, etc)
- Available technologies and facility types
- Social and regulatory

For this study
You want to be here

Goal should be to minimize short-term and long-term risks

Tailings Management Strategy Considerations

- Tailings Characteristics and Scale
- Site Conditions
- Available Technologies and Facility Types
Tailings Management Strategy Considerations

- Physical properties (grain size, rheology, plasticity, etc.)
- Chemical properties (of solids and process water)
- Mill production rate and anticipated throughput.

Tailings Characteristics and Scale

Available Technologies and Facility Types

Site Conditions
## Physical Tailings Properties

<table>
<thead>
<tr>
<th>Tailings Type</th>
<th>Symbol</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse tailings</td>
<td>CT</td>
<td>Salt, mineral sands, coarse coal rejects, iron ore sands,</td>
</tr>
<tr>
<td>Hard rock tailings</td>
<td>HRT</td>
<td>Copper, massive sulphide, nickel, gold,</td>
</tr>
<tr>
<td>Altered rock tailings</td>
<td>ART</td>
<td>Porphyry copper with hydrothermal alteration, oxidized rock</td>
</tr>
<tr>
<td>Fine tailings</td>
<td>FT</td>
<td>Fine coal rejects, bauxite residue (red mud)</td>
</tr>
<tr>
<td>Ultra fine tailings</td>
<td>UFT</td>
<td>Oil sand (mature fine tailings - MFT), phosphate fines, some kimberlite and coal fines</td>
</tr>
</tbody>
</table>

Reference: ICOLD 2017
Tailings types have been simplified to classify tailings based on management strategies and potential water quality outcomes.

Source: GARD Guide, INAP 2009
Other Considerations:

- Supernatant quality (use of process reagents, treatment, and settling time);
- Production rate;
- Scalability of technology;
- Effectiveness of technology types on material properties (e.g. is a material too fine and plastic to filter?).
Tailings Management Strategy Considerations

Tailings Characteristics and Scale

Available Technologies and Facility Types

Site Conditions
Conventional Facility

Discharge to Environment

Water Treatment

Tailings Dewatering

Tailings Dam

Tailings Beach

Tailings Pond

Seepage Recovery Pond

Seepage Recovery Dam

Mill

Majority of water storage

Makeup Water

Non-Contact Water

Contact Water

Tailings
Thickened/Paste Facility

Facility Types

Mill

Discharge

Water Treatment

Tailings

Dewatering

Makeup Water

Runoff Collection Dam

Majority of water storage

* Downslope or cone deposition
Filtered Facility

Facility Types

Discharge to Environment

Water Treatment

Tailings Dewatering

Collection Pond

Runoff Collection Dam

Mill

Structural Zones

Filtered Tailings Pile

Majority of water storage

Non-Contact Water

Contact Water

Tailings
Tailings Management Strategy Considerations

- Tailings Characteristics and Scale
- Available Technologies and Facility Types
- Site Conditions
Design Targets

High-Density Thickened/Paste Tailings

Target moisture content to achieve non-segregating behavior, deposition slopes, no bleed water

Filtered Tailings

Target moisture content for compaction to achieve non-liquefiable mass

Image Reference: Paterson & Cooke 2017
Physical Tailings Properties Affect Dewatering Potential

More Difficult to Achieve and Transport

Yield Stress (Pa)

More Dewatered

Solids Content (%)

Positive-Displacement Pump

Centrifugal Pump

Image reference: ICOLD 2017
Tailings Management Strategy Considerations

- Tailings Characteristics and Scale
- Available Technologies and Facility Types
- Site Conditions
Climate and Production Scale

Note: only facilities that are included in the case history review or provided a questionnaire response are included in the graph. **Not just Canadian Projects.**
THICKENED TAILINGS

Typical % solids ranging from approximately from ~40% to ~60%

Note: only facilities that are included in the case history review or provided a questionnaire response are included in the graph. Not just Canadian Projects.
Climate and Production Scale

PASTE and HIGH DENSITY THICKENED TAILINGS

Typical % solids ranging from approximately from ~60% to 75%

Note: only facilities that are included in the case history review or provided a questionnaire response are included in the graph. Not just Canadian Projects.
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Tailings Dewatering Projects in Canada Research

Information Collected Through:

- a questionnaire sent to ~**260 recipients** in mining companies requesting basic information on site characterization, tailings properties and tailings dewatering technologies. **Thirty-six (36) project** replies were received;
- KCB’s library and previous projects files (more than 60 years of projects);
- literature search conducted by KCB’s professional librarian;
- contacts within the mining industry;
- contacts with KCB mining clients;
- contacts with associations and organizations such as International Commission on Large Dams (ICOLD), Mining Association of Canada (MAC), Canadian Dam Association (CDA); and
- contacts with provincial, territorial and federal government agencies.
Tailings Dewatering Projects in Canada Results

Dewatering Technology
- Thickened
- High-density
- Paste
- Filtered

Facility Type
- Conventional
- High-Density Thickened / Paste
- Filtered

Klohn Crippen Berger
### Tailings Dewatering Projects in Canada Results

<table>
<thead>
<tr>
<th>Dewatering Technology</th>
<th>Number of Canadian Facilities</th>
<th>Facility Type</th>
<th>Number of Canadian Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickened (above 50% solids by weight)</td>
<td>7</td>
<td>Conventional</td>
<td>10</td>
</tr>
<tr>
<td>High-density Thickened (above 60% solids by weight)</td>
<td>5</td>
<td>High-Density Thickened/Paste</td>
<td>3*</td>
</tr>
<tr>
<td>Paste (above ~70% solids by weight, requires positive displacement pump)</td>
<td>1</td>
<td>Filtered</td>
<td>9*</td>
</tr>
<tr>
<td>Filtered (above 80% solids by weight, cannot be pumped)</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>22</strong></td>
<td></td>
<td><strong>22</strong></td>
</tr>
</tbody>
</table>