MEND

Study of Tailings Management Technologies

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Presentation Outline

1. **Introduction**
   - Study Objectives
   - Methodology
   - Spoiler Alert: Key Conclusion
2. **Tailings Management Strategy Considerations**
   - Tailings Properties
   - Site Conditions
   - Dewatering Techntechnologies 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.

Image Reference: COSIA 2017

Study “Disclaimer”

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 rep

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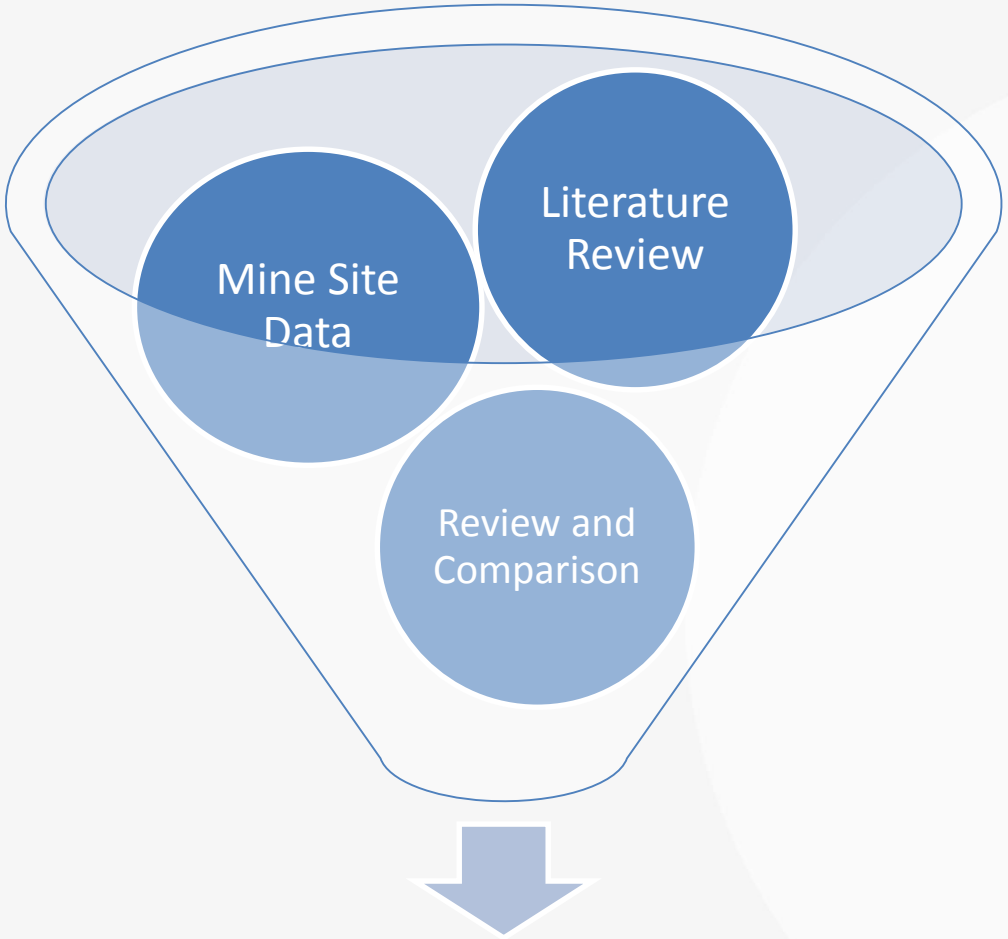
1) Conclusions are generalized, undoubtedly there will be exceptions

2) The scope of this study does not cover everything, in particular: dam design and closure design that is unrelated to tailings dewatering

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.

Study Methodology



Current State of Practice/ Gaps/ Lessons Learned

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.

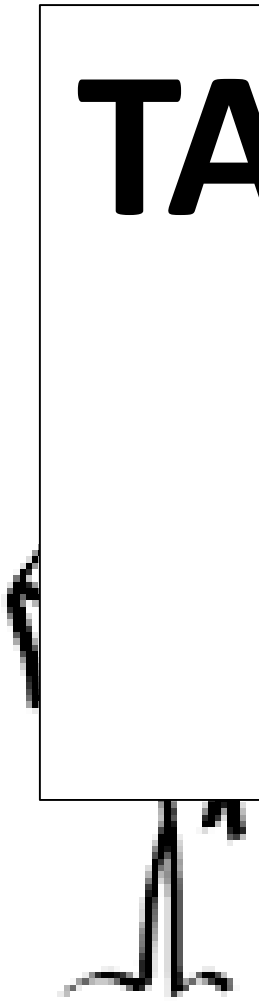
NO ONE-SIZE-FITS-ALL Technology for Tailings Management

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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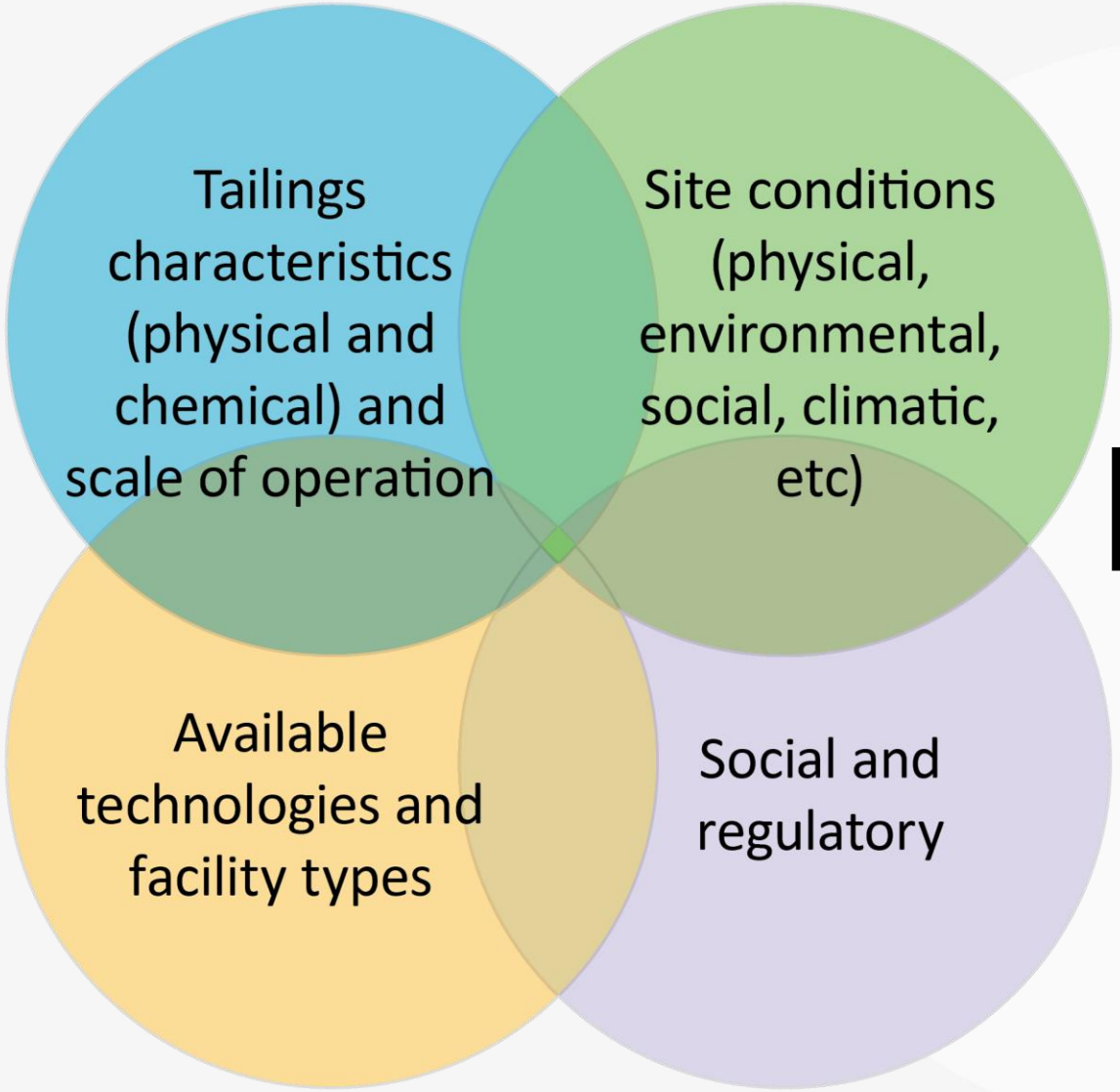
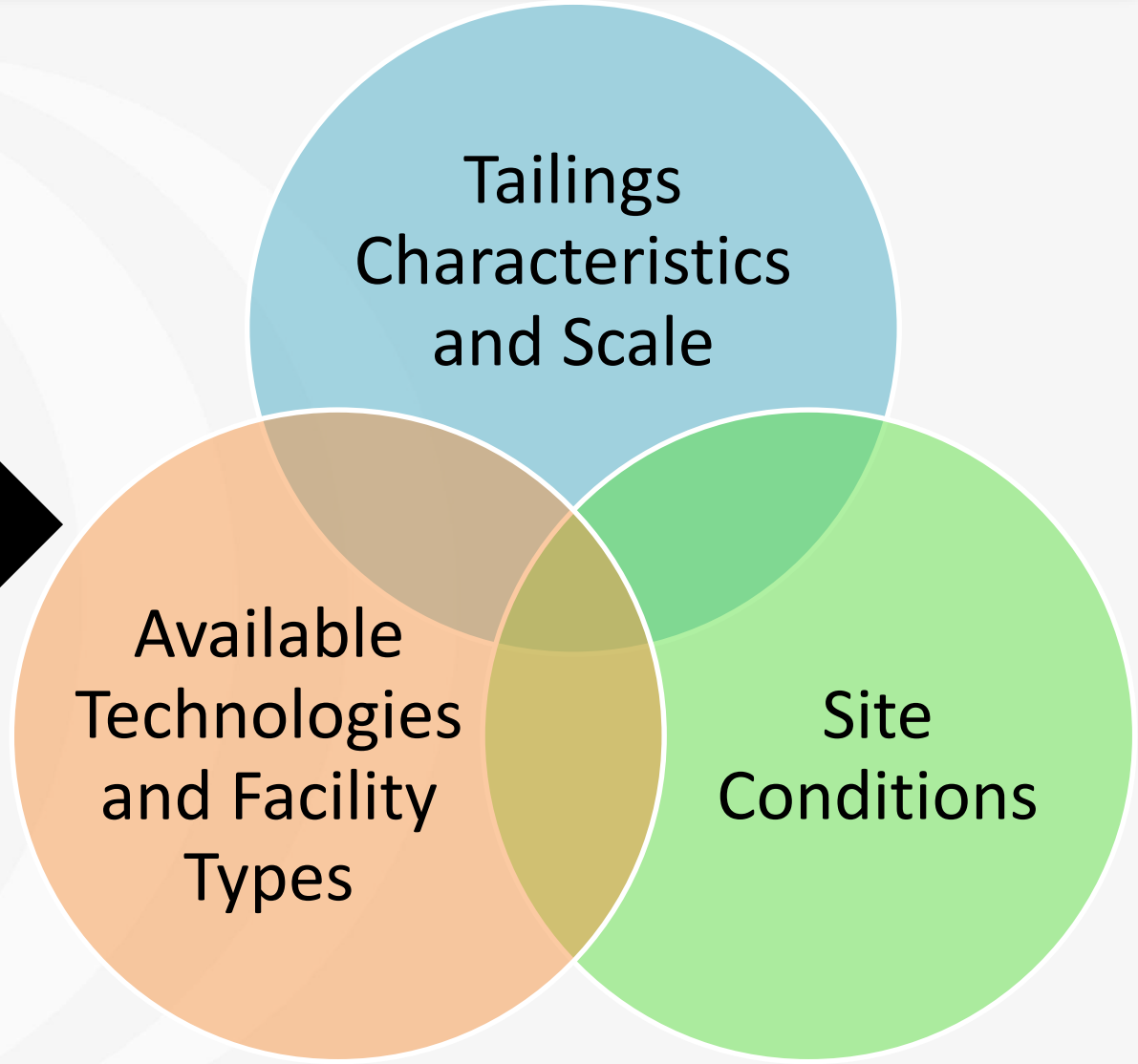
Tailings Management Strategy Considerations



For this study



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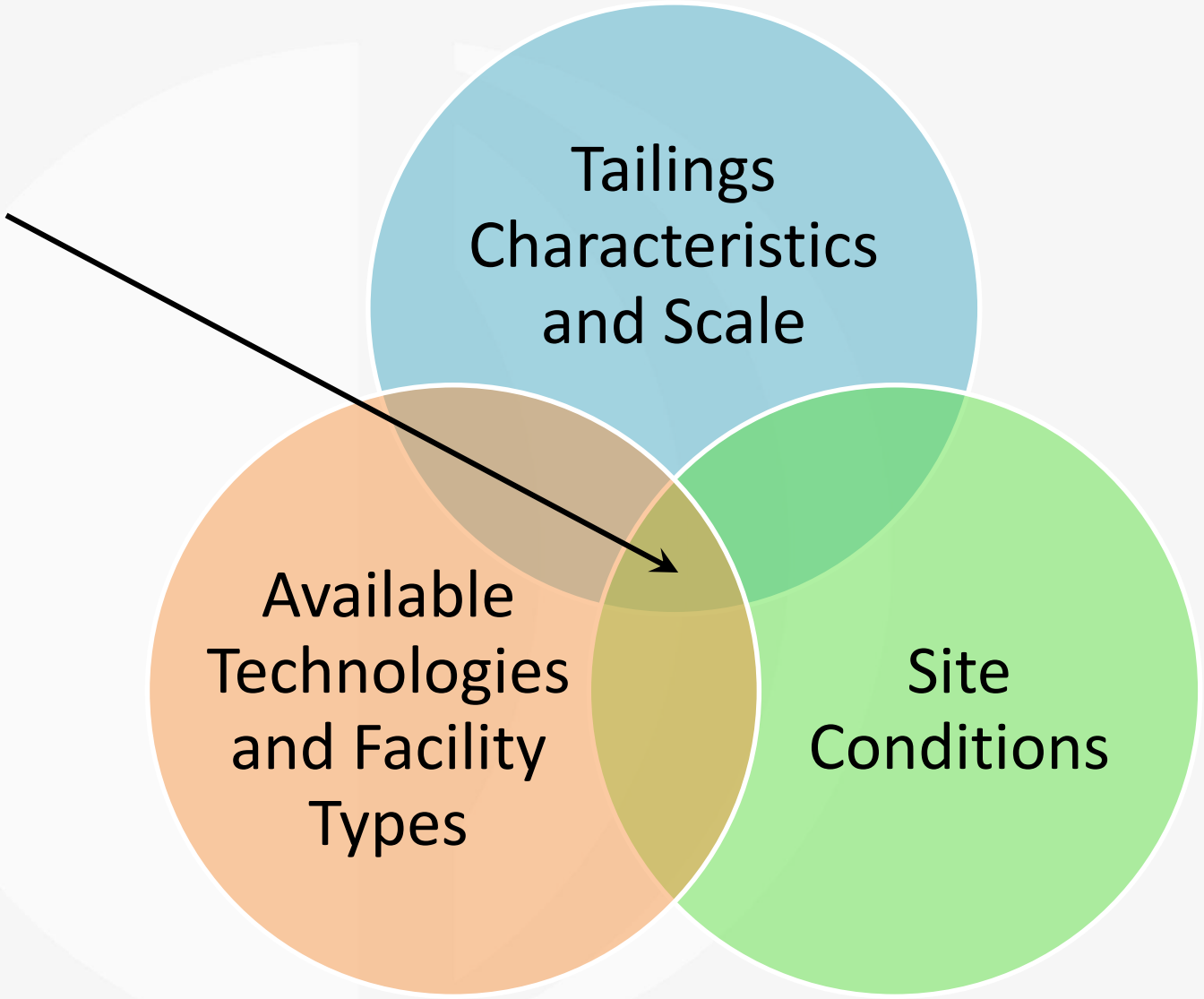
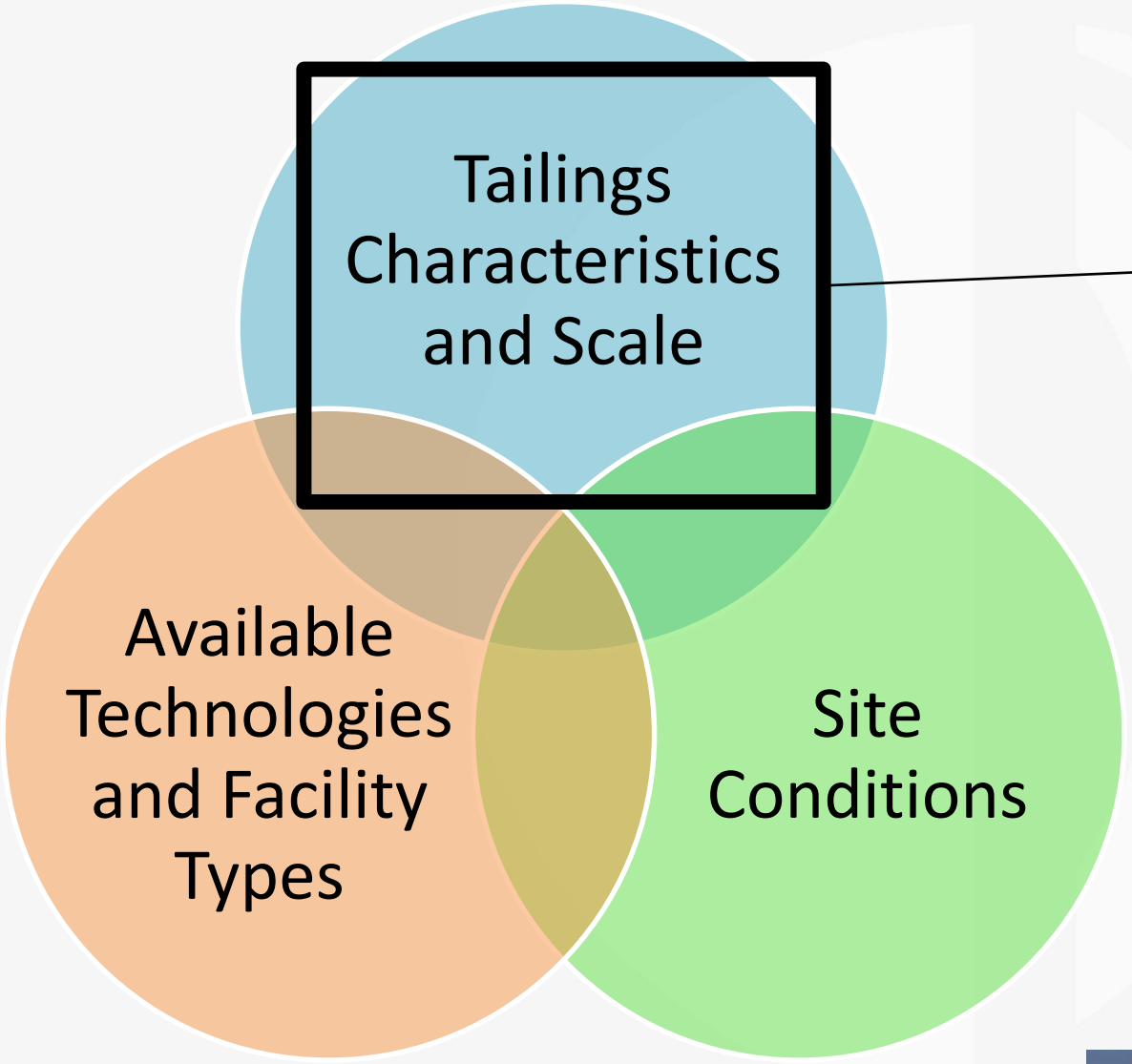
Tailings Management Strategy Considerations

You want to be here

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



Tailings Management Strategy Considerations

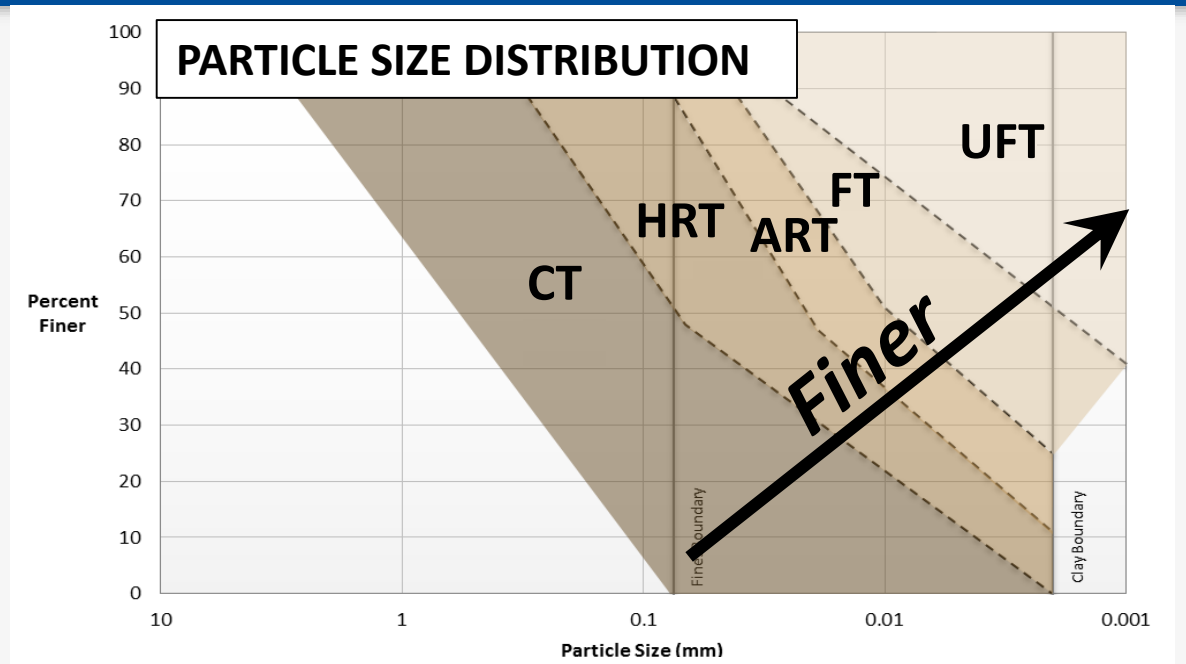


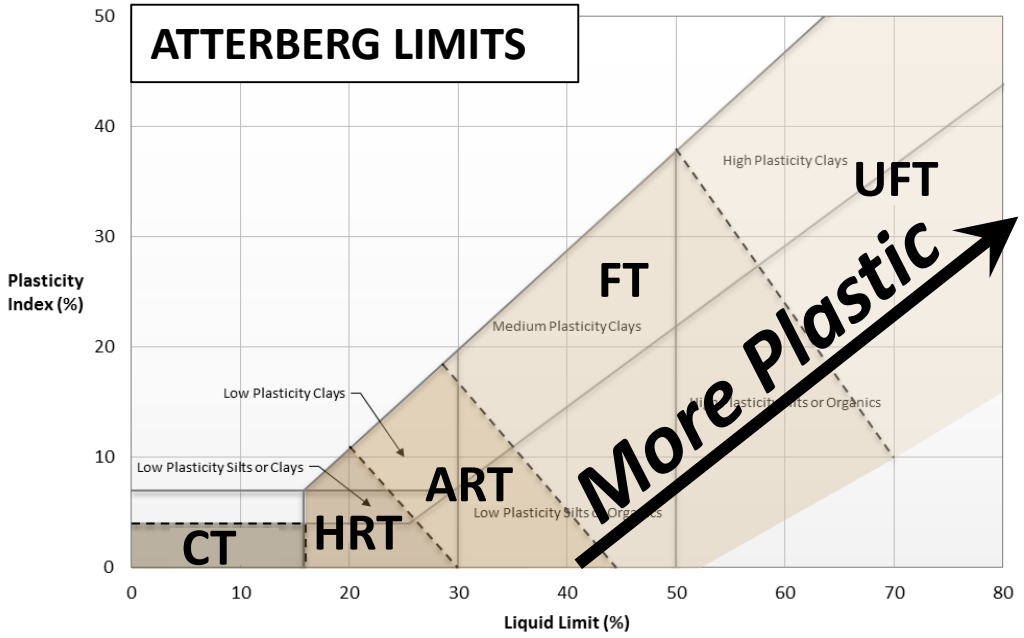
- Physical properties (grain size, rheology, plasticity, etc.)
- Chemical properties (of solids and process water)
- Mill production rate and anticipated throughput.

Physical Tailings Properties

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

Reference: ICOLD 2017





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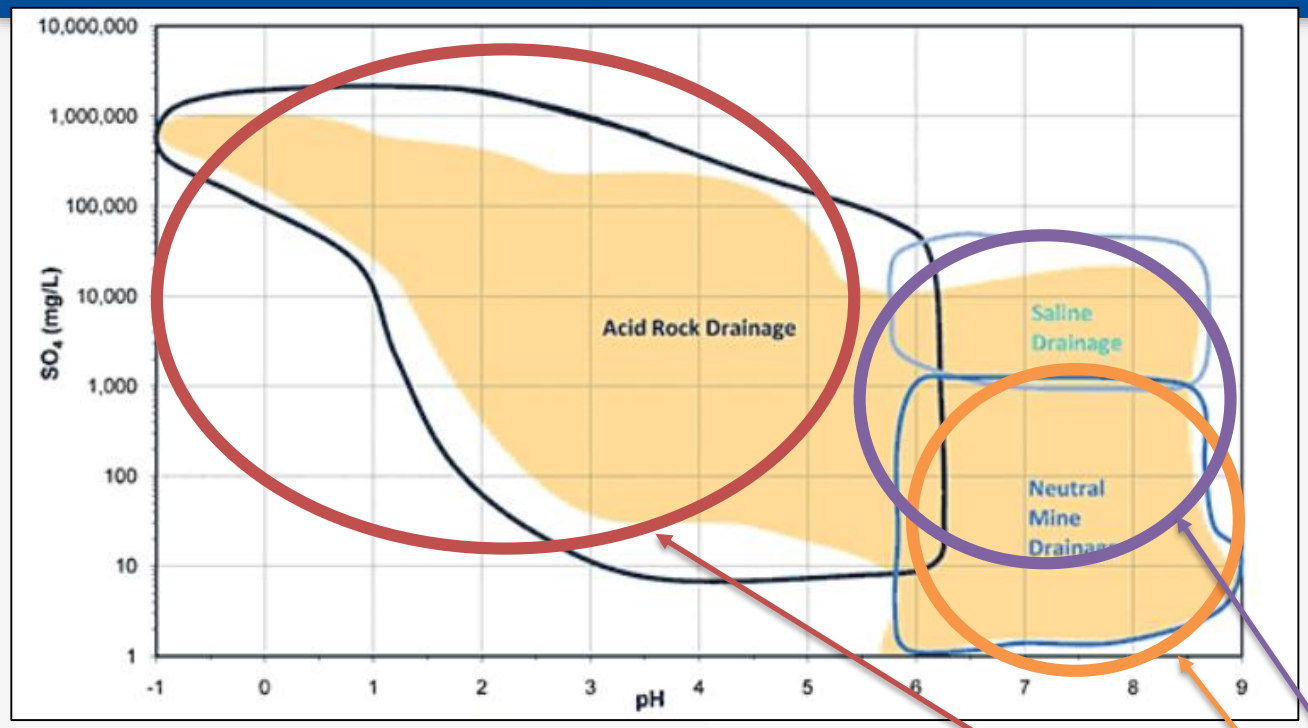
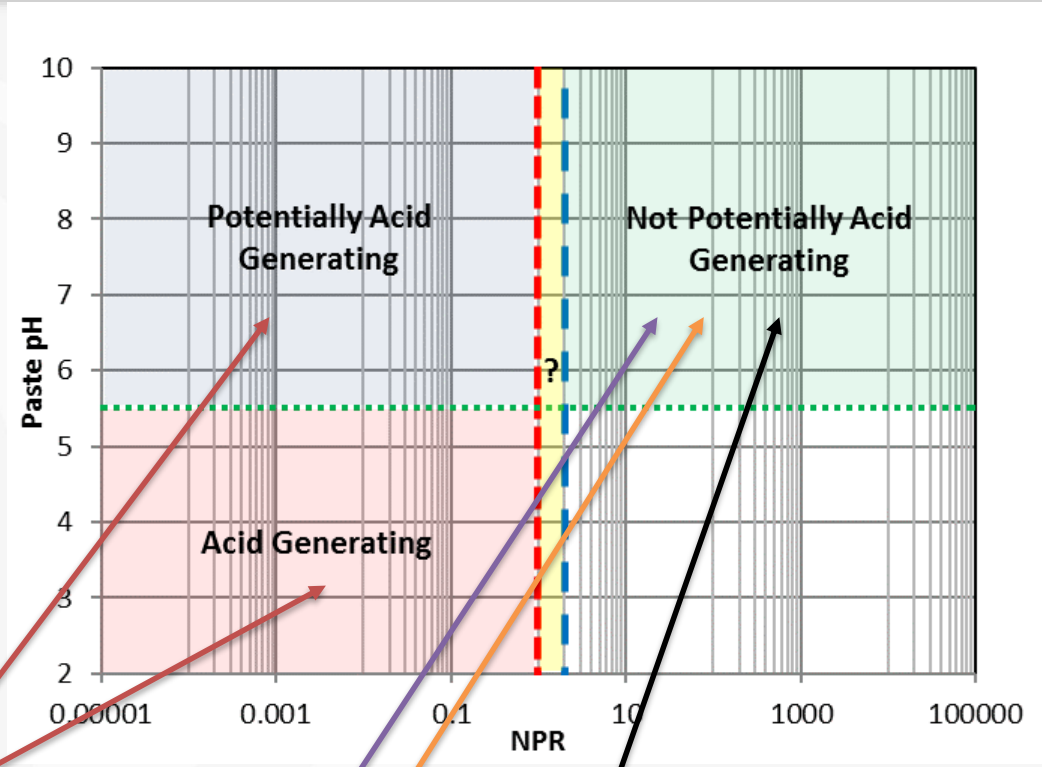
Chemical Tailings Properties



Source: GARD Guide, INAP 2009



Sulphidic ML/ARD

Sulphidic ML

Low Reactivity

Non-Sulphidic Leaching

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

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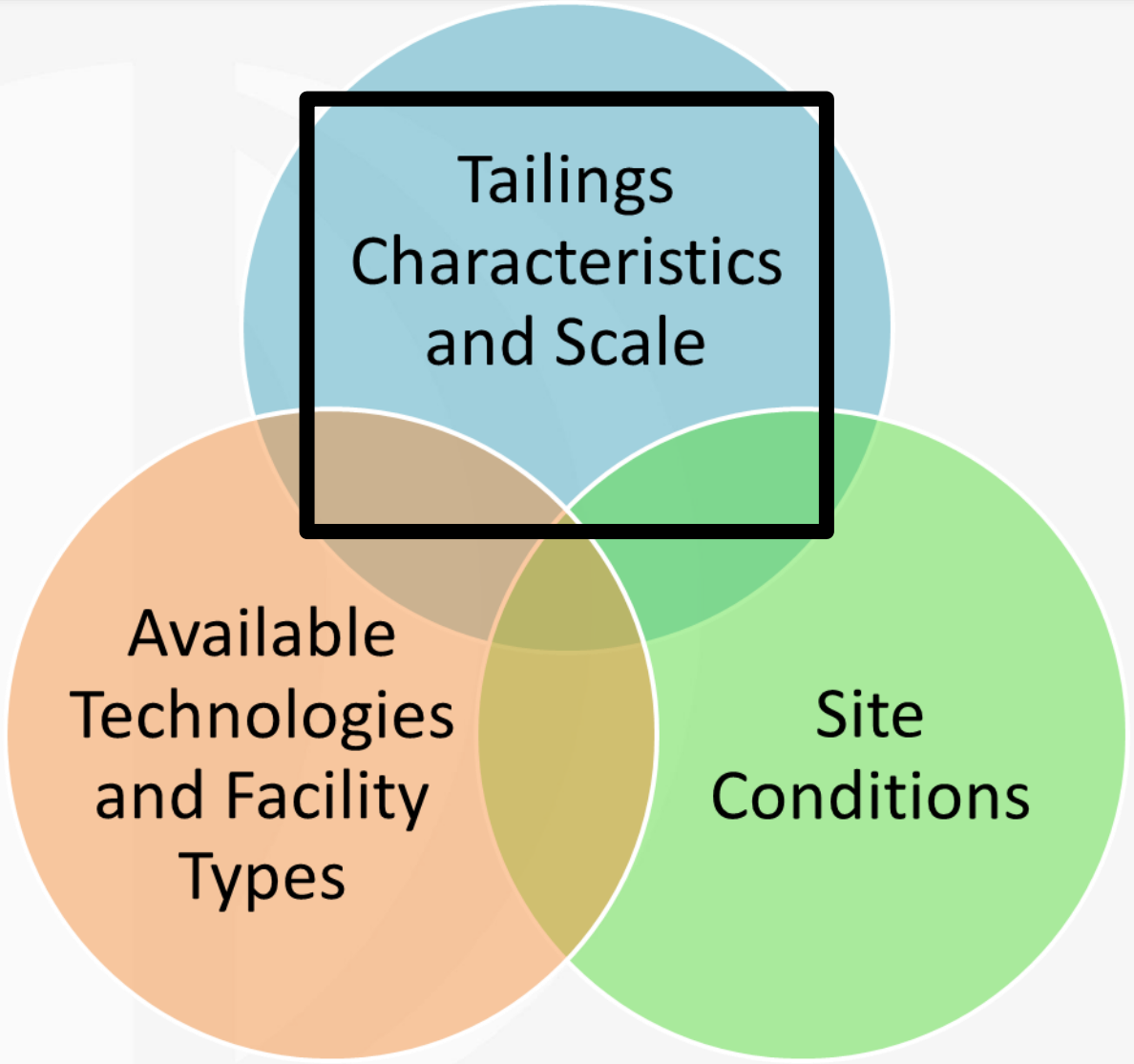
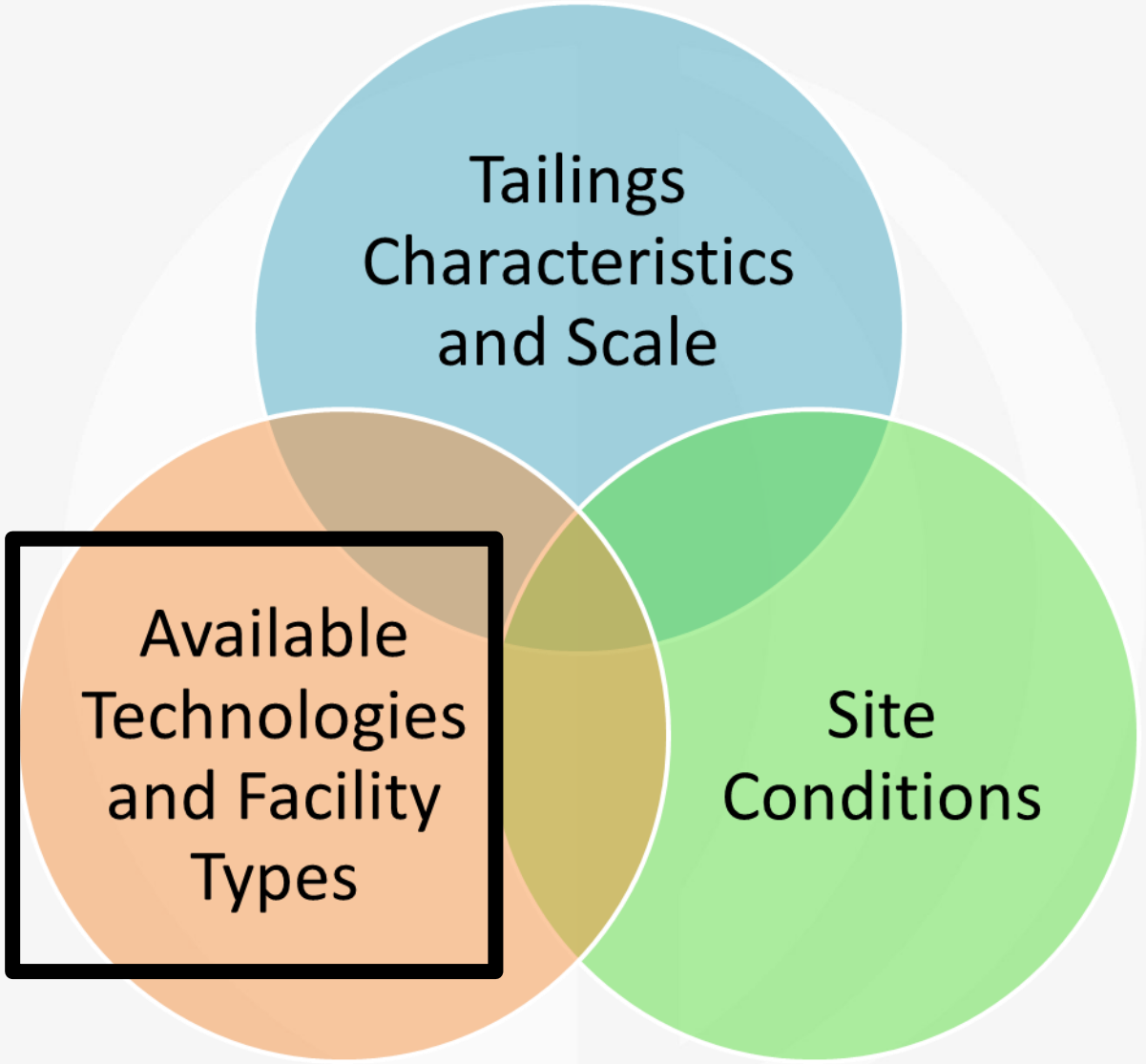
Tailings Management Strategy Considerations

Other Considerations:

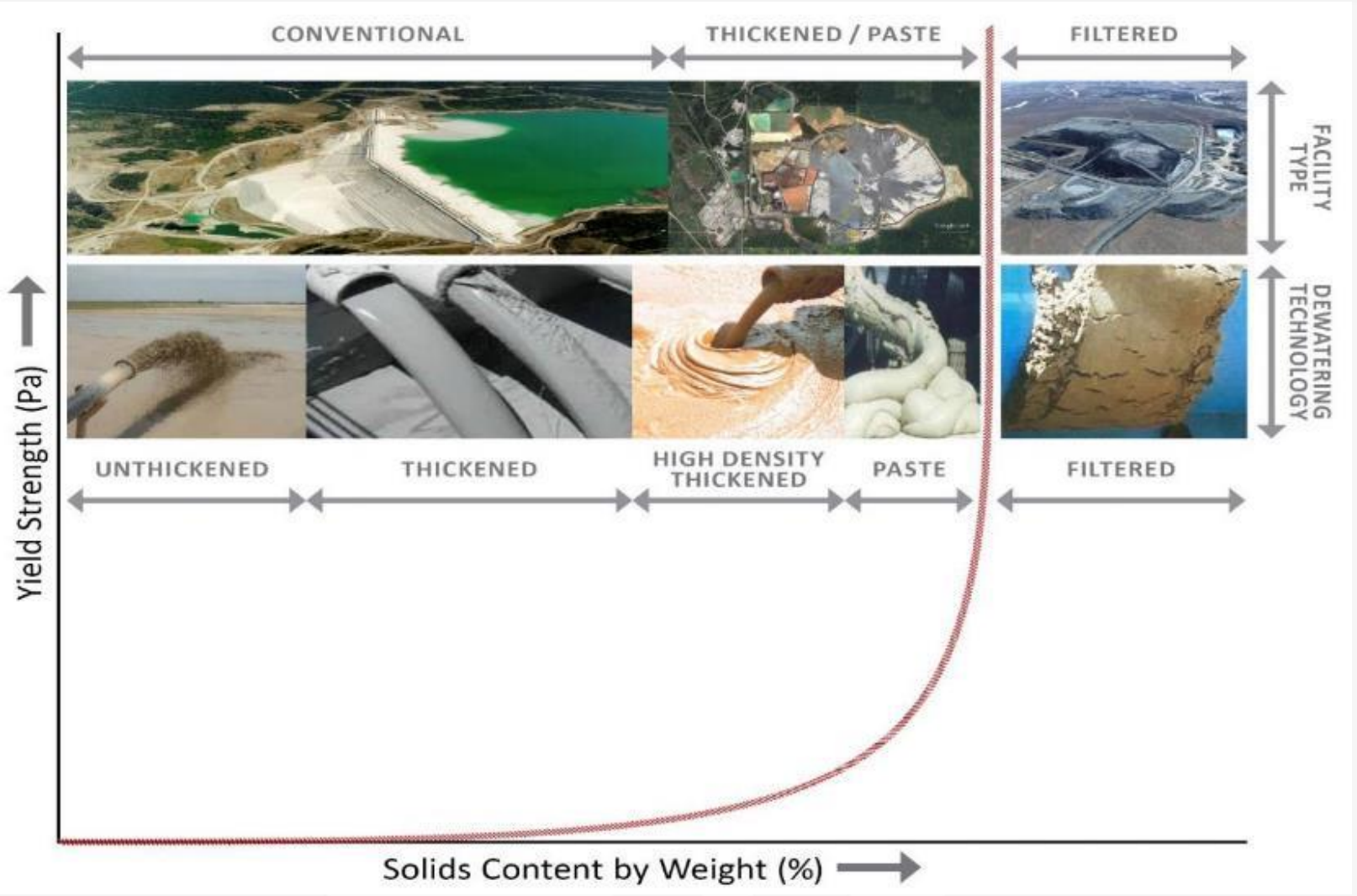
- Supernatant quality (use of process reagents, treatment, and settling time);
- Production rate;
- Scalability of technology;
- Effectiveness of technology types on material properties (e.g. is a material too fine and plastic to filter?).



Tailings Management Strategy Considerations



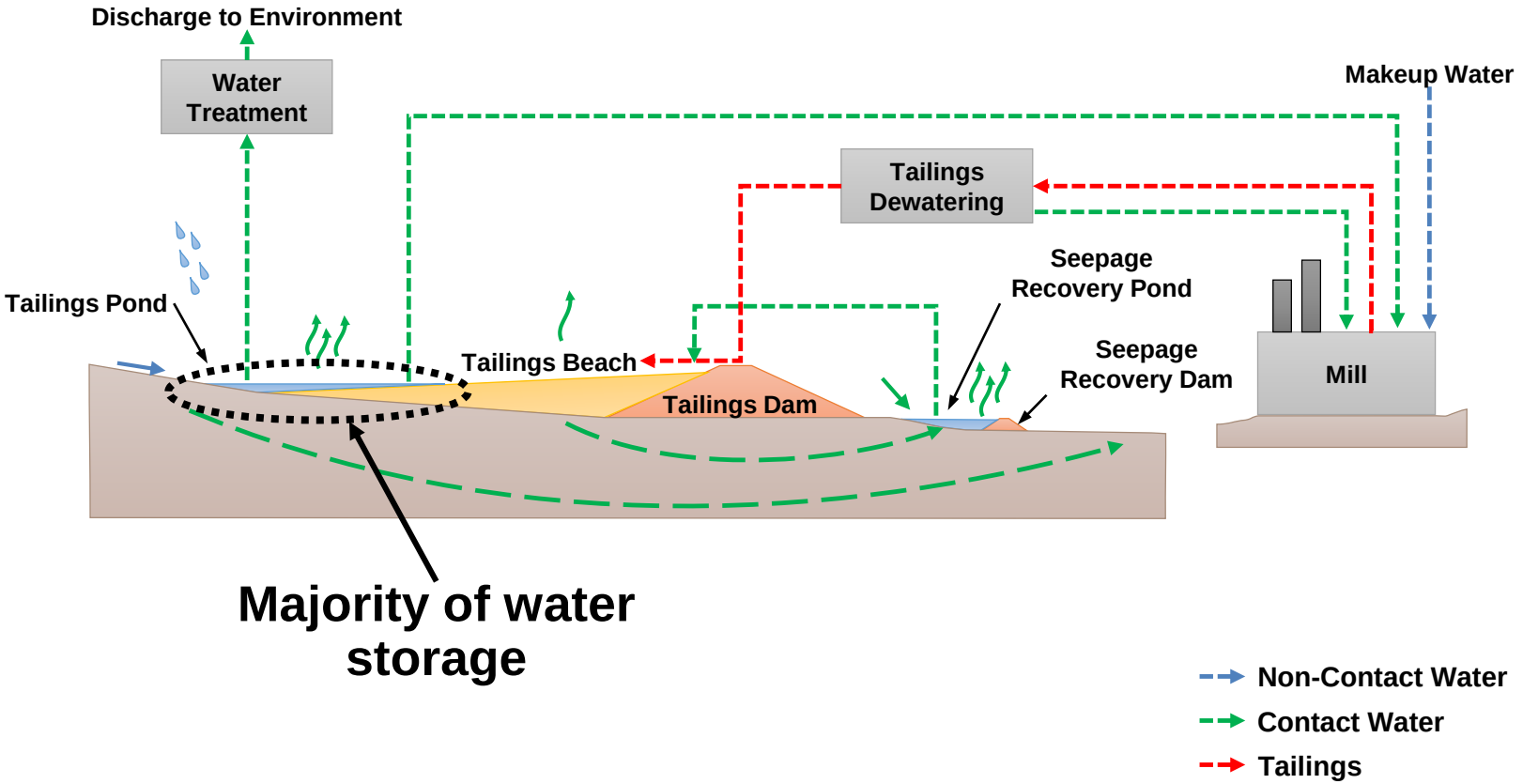
Tailings Dewatered States and Facility Types



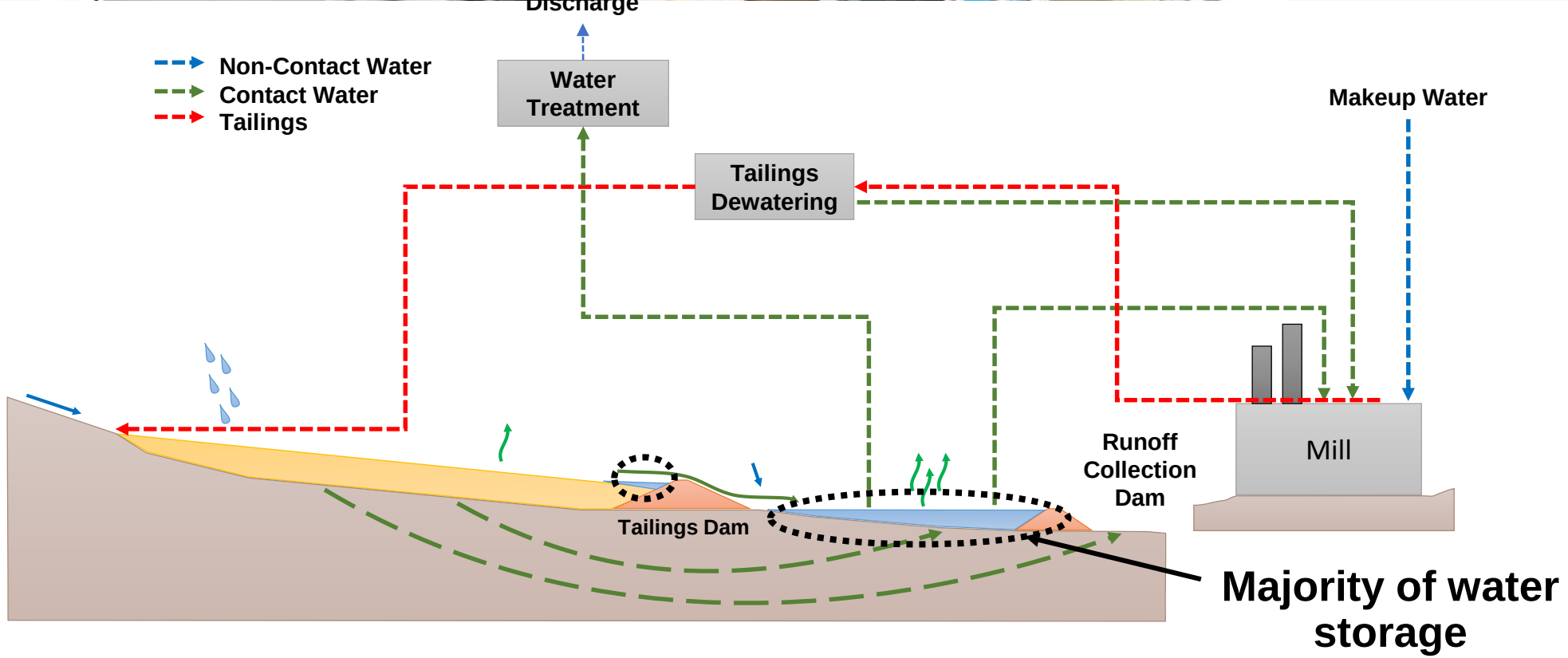
Facility type images (left to right): KCB 2017, Google 2016 & © Digital Globe 2016, Levac 2016
Dewatering technologies images: Fourie 2015 and Jewell and Fourie 2015
Ingredients: Meredith 2017, Mother Earth News 2014, Quora 2015, Barefeet 2013

Facility Types

Conventional Facility



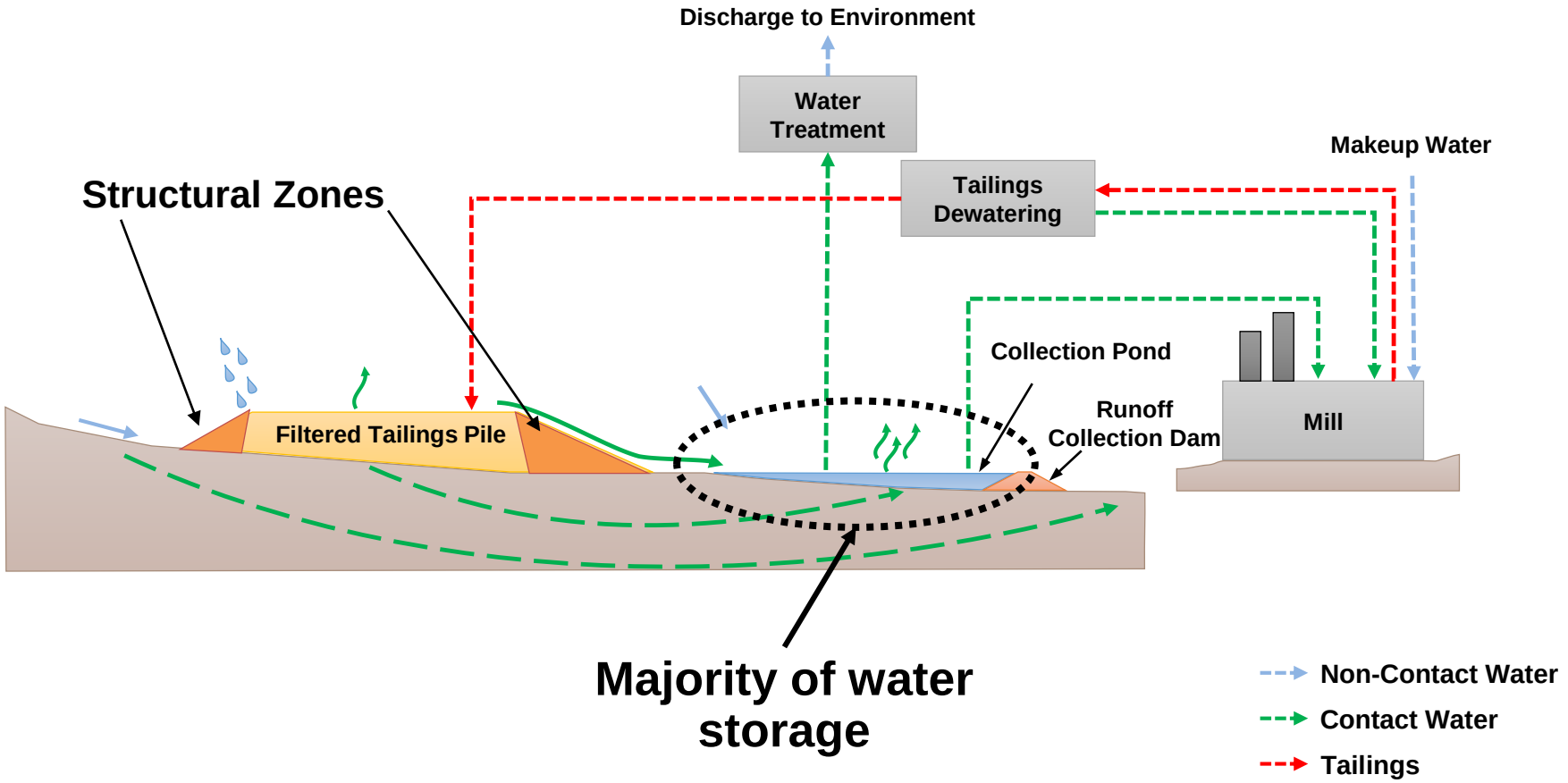
Thickened/Paste Facility



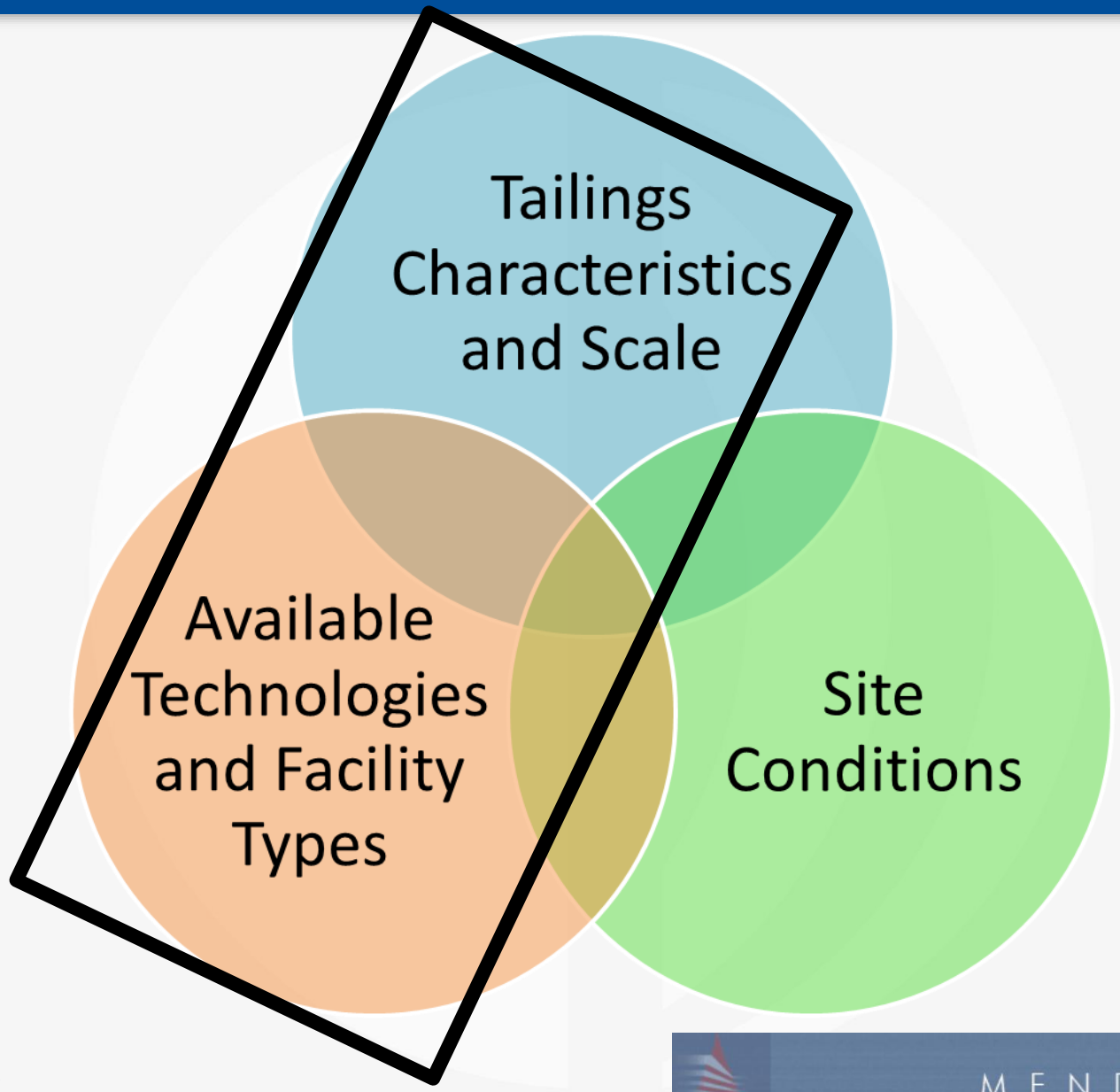
** Downslope or cone deposition*

Facility Types

Filtered Facility



Tailings Management Strategy Considerations



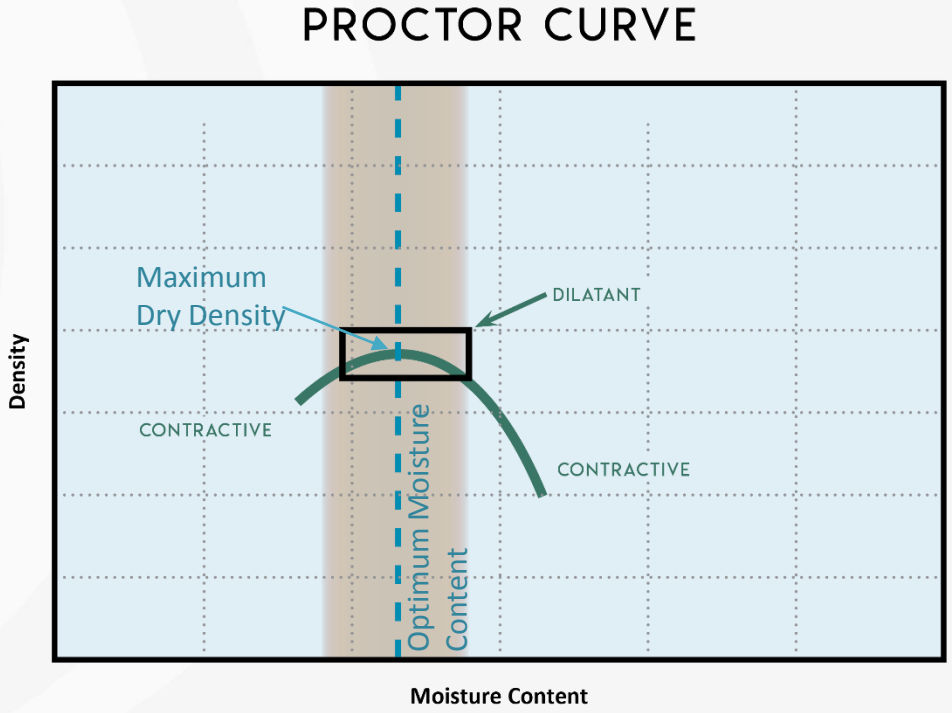
High-Density Thickened/ Paste Tailings

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

Image Reference: Paterson & Cooke 2017

Filtered Tailings

Target moisture content for compaction to achieve non-liquefiable mass



Physical Tailings Properties Affect Dewatering Potential

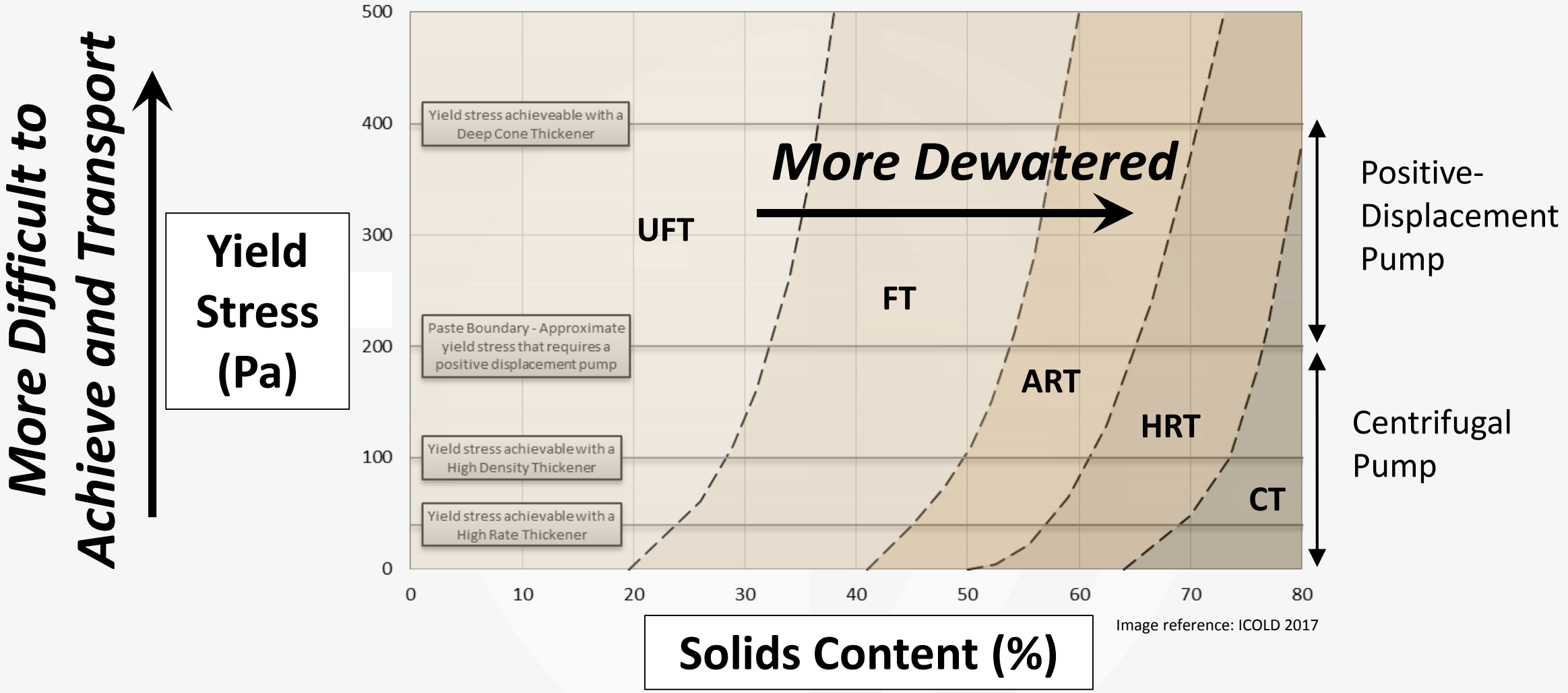
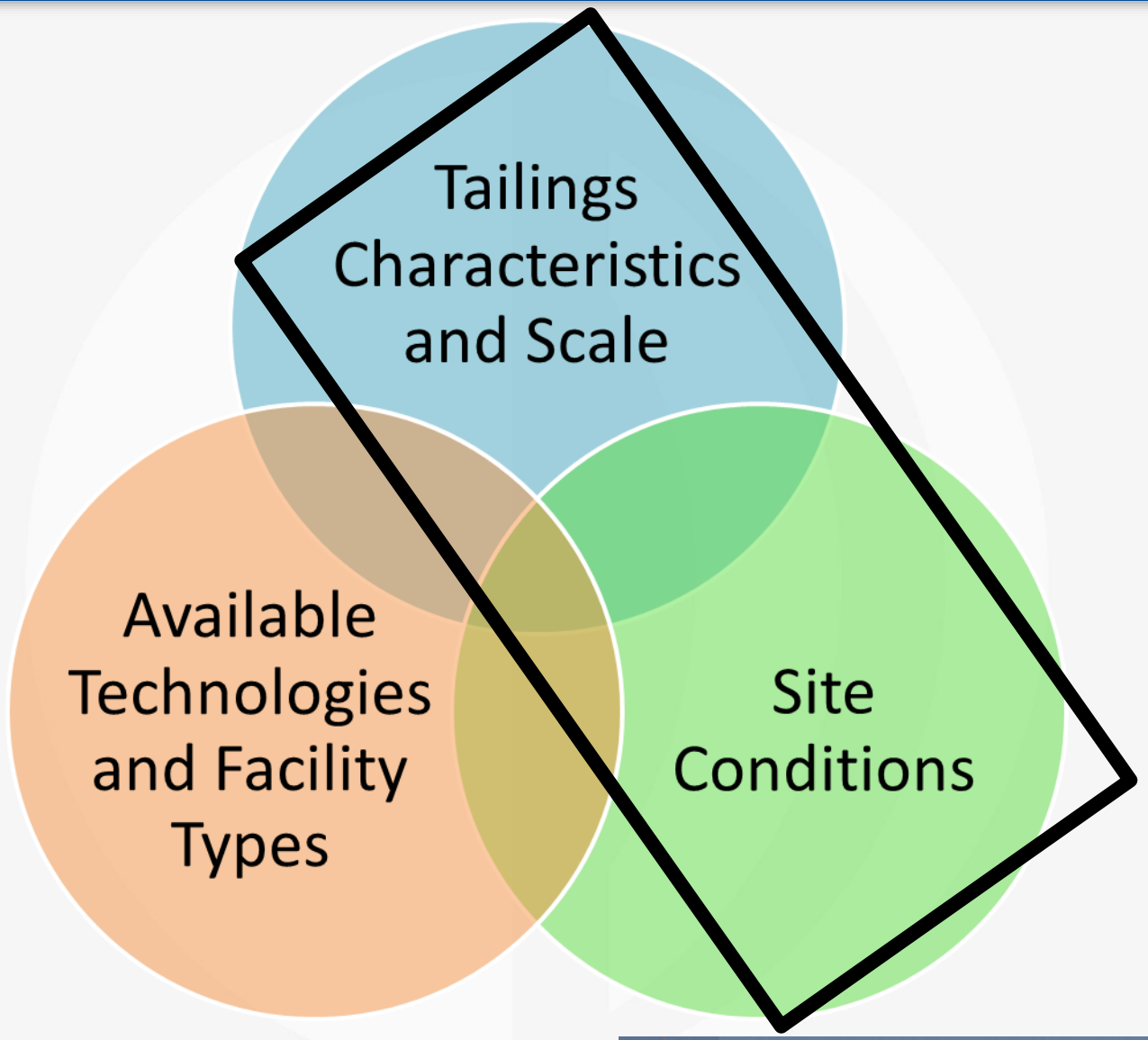
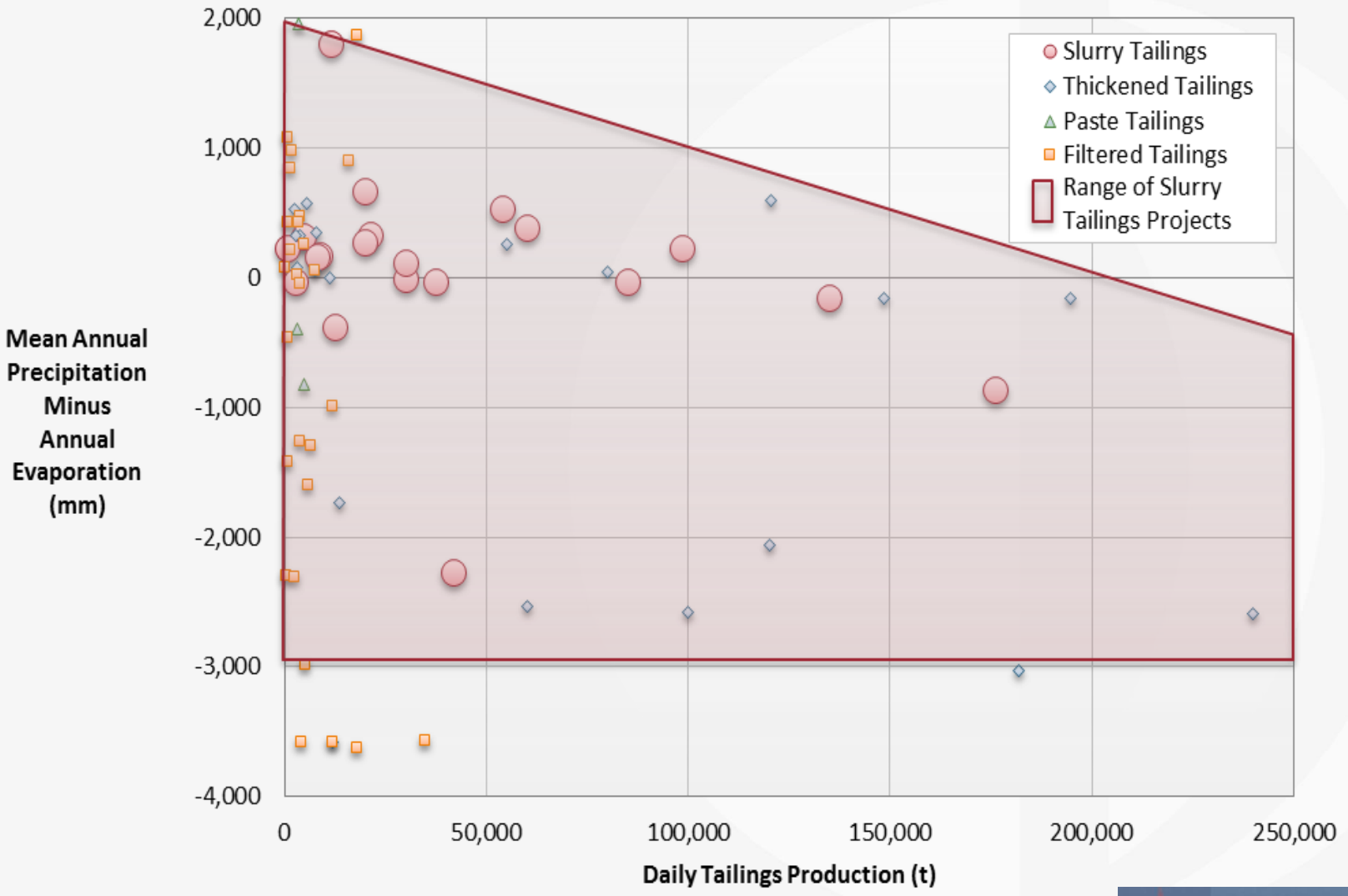


Image reference: ICOLD 2017

Tailings Management Strategy Considerations



Climate and Production Scale

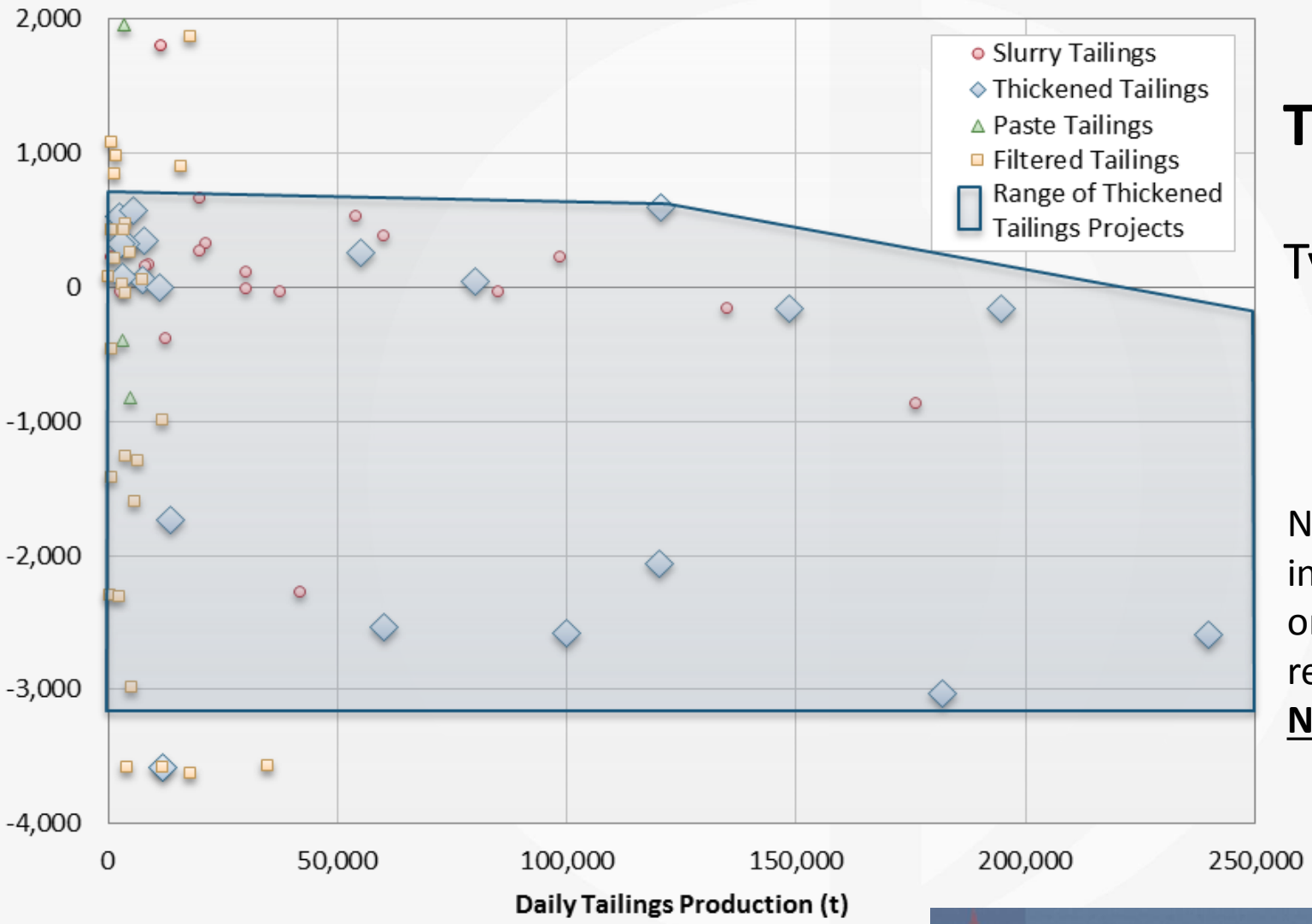


CONVENTIONAL TAILINGS

Typical % solids ranging from approximately from ~20% to ~40%

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

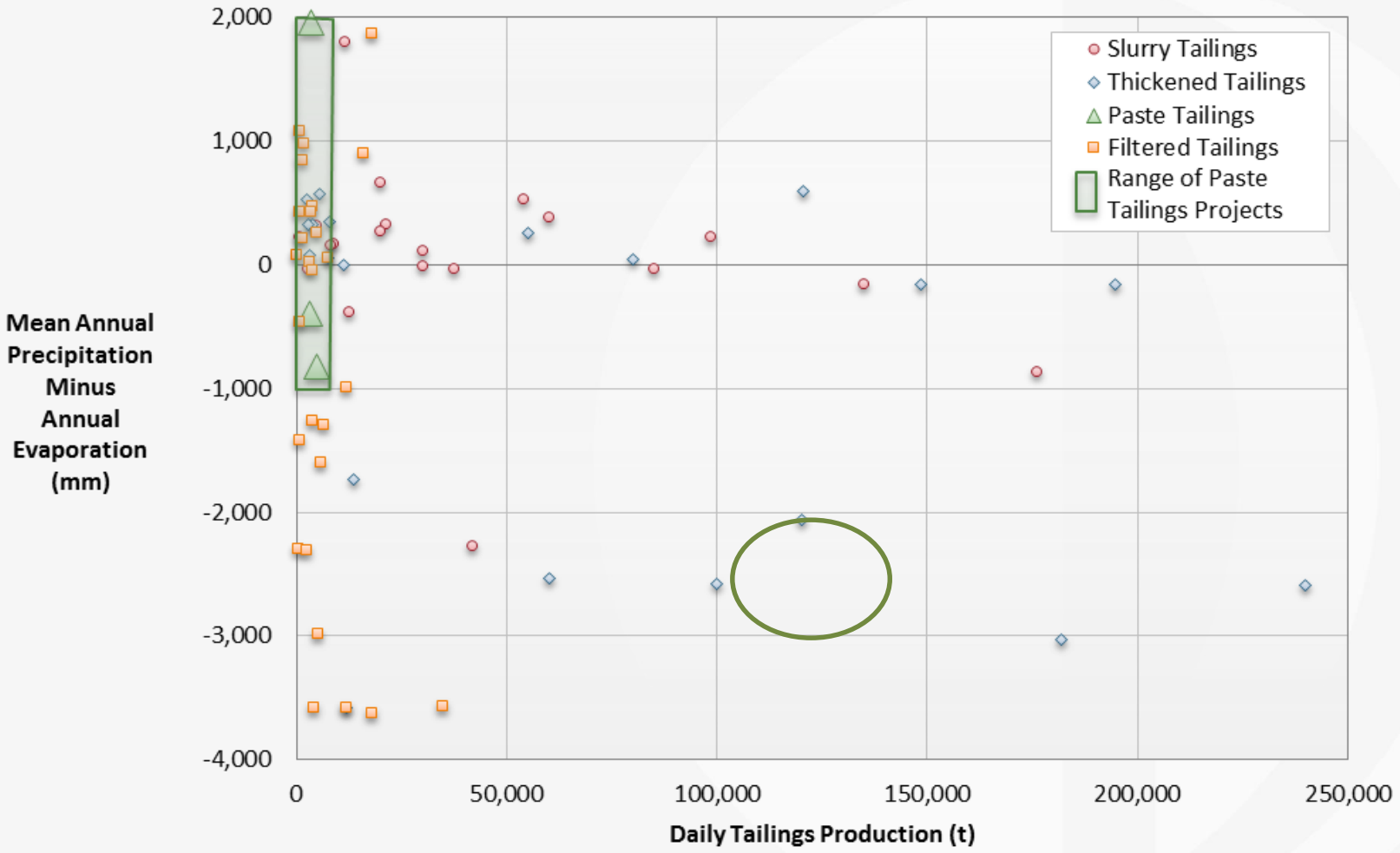


THICKENED TAILINGS

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

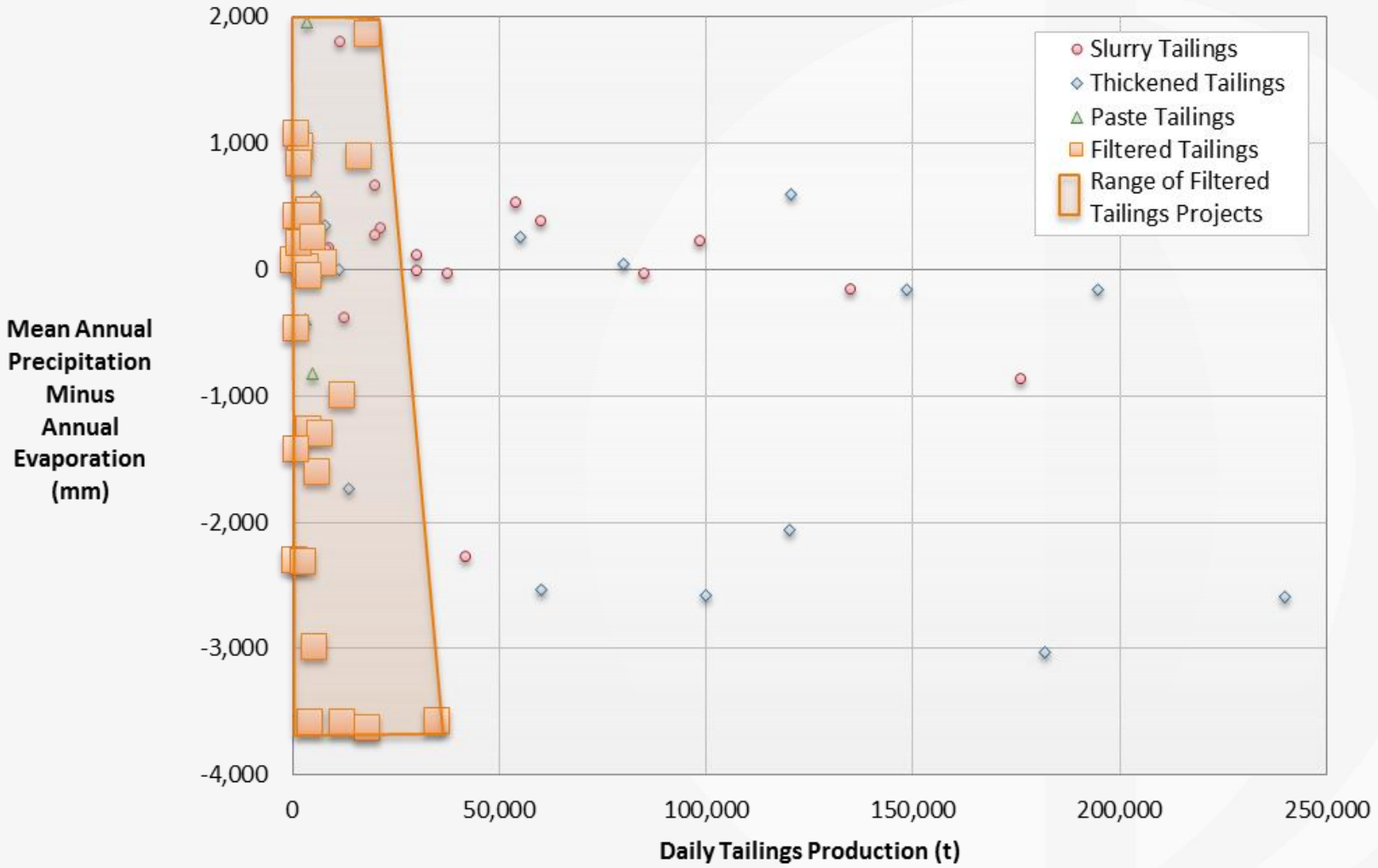


PASTE and HIGH DENSITY THICKENED TAILINGS

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.**

Climate and Production Scale



FILTERED TAILINGS

Typical % solids ranging from approximately from ~>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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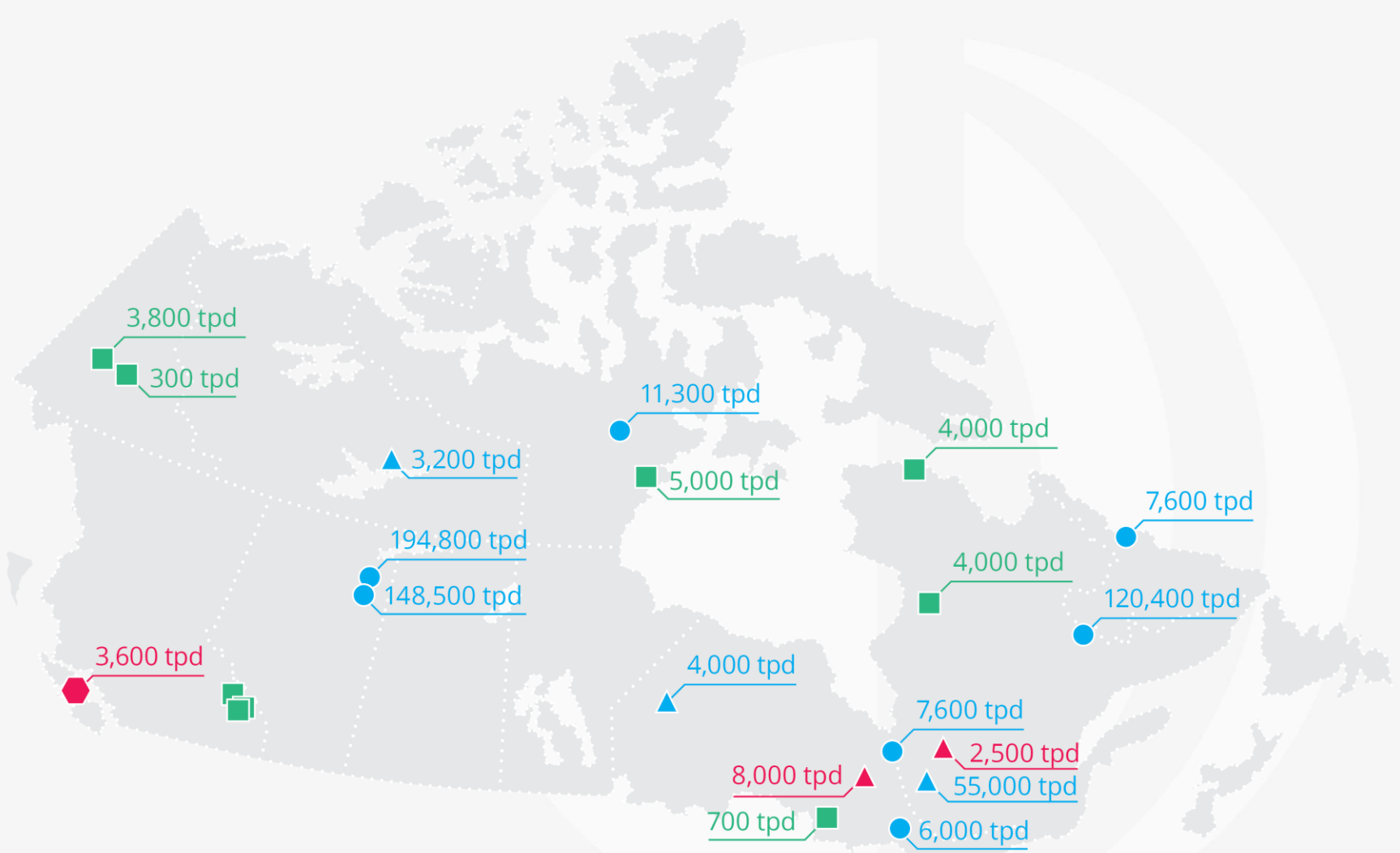
Tailings Dewatering Projects in Canada Research

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

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Tailings Dewatering Projects in Canada Results

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