CENTRE FOR ENERGY AND ENVIRONMENTAL SUSTAINABILITY

BENCH-SCALE EVALUATION OF CHEMISTRY FOR FLUID FINE TAILINGS (FFT) TREATMENT

REGULATORY DRIVERS AND OPERATIONAL CONSIDERATIONS

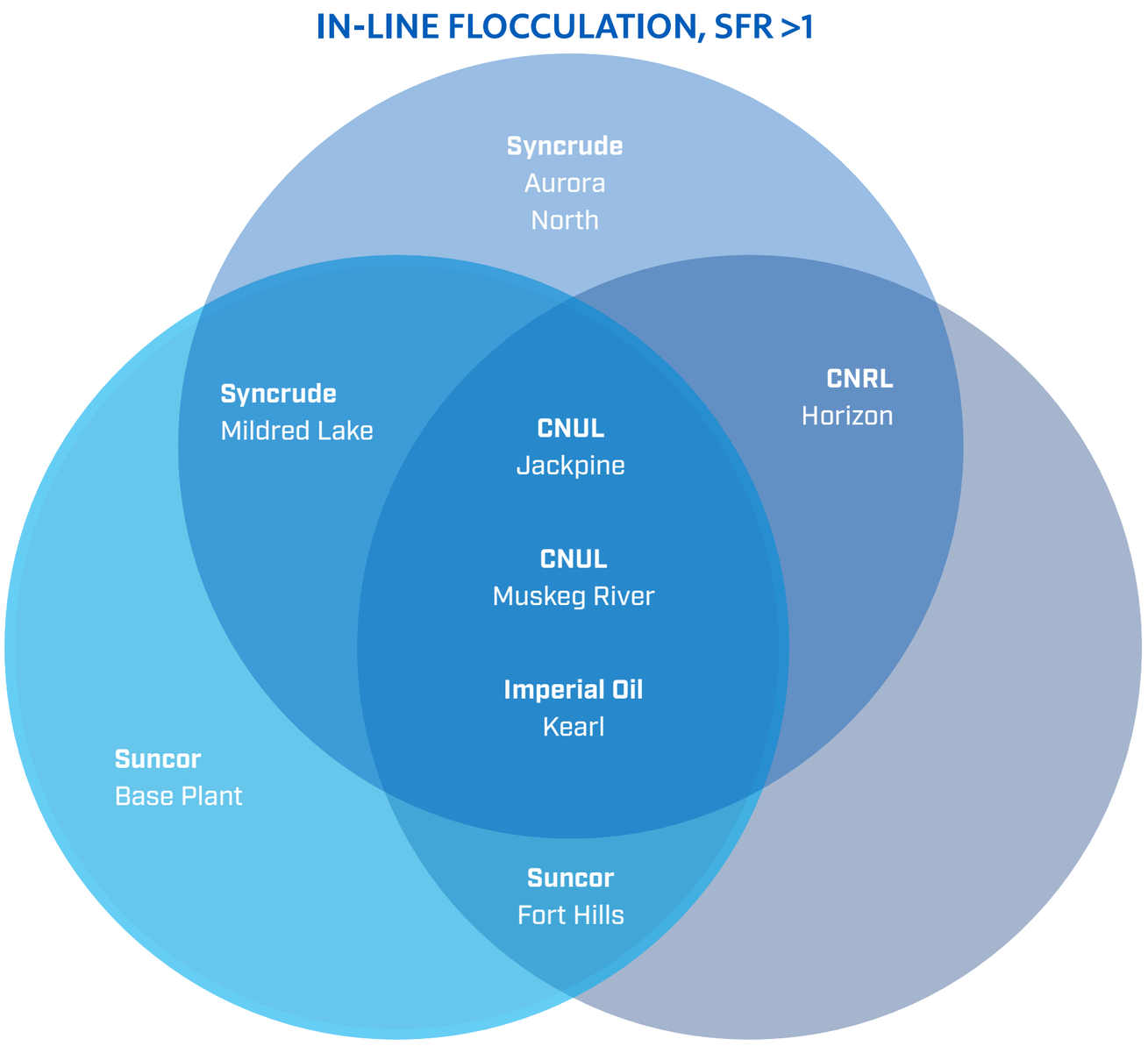
In oil sands, fluid tailings are defined as any slurry byproducts from bitumen extraction facilities containing **more than 5 wt.% suspended solids** and having an **undrained shear strength of less than 5 kPa [1].**

The **Alberta Energy Regulator (AER)** has implemented **Directive 085 (2022)** for progressive reclamation to ensure that all fluid tailings associated with a project are **Ready To Reclaim (RTR)** ten years after the end of mine life.

AER outlines that fluid tailings are considered RTR when they have been **treated, placed in their final landscape position**, and **met performance criteria** defined by individual operators working under the **Tailings Management Framework (TMF) [1]**.

To achieve these requirements, the sites currently employ different technologies such as **in-line flocculation** and **thickeners** depending on tailings characteristics such as the sand to fines ratio (SFR)[1] and overall reclamation strategy. In addition, some operators will add **coarse material**[1] to adjust the SFR to be within process specifications.

As a result, each site has **unique needs and evaluation protocols** when it comes to assessing chemistry.

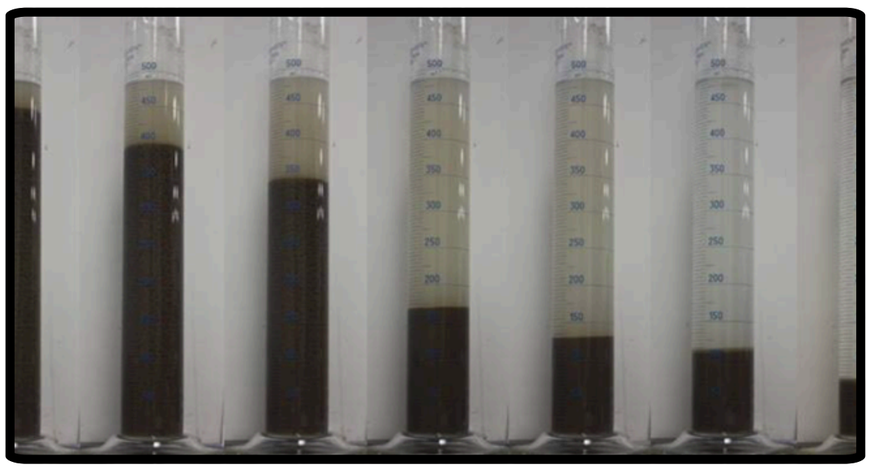
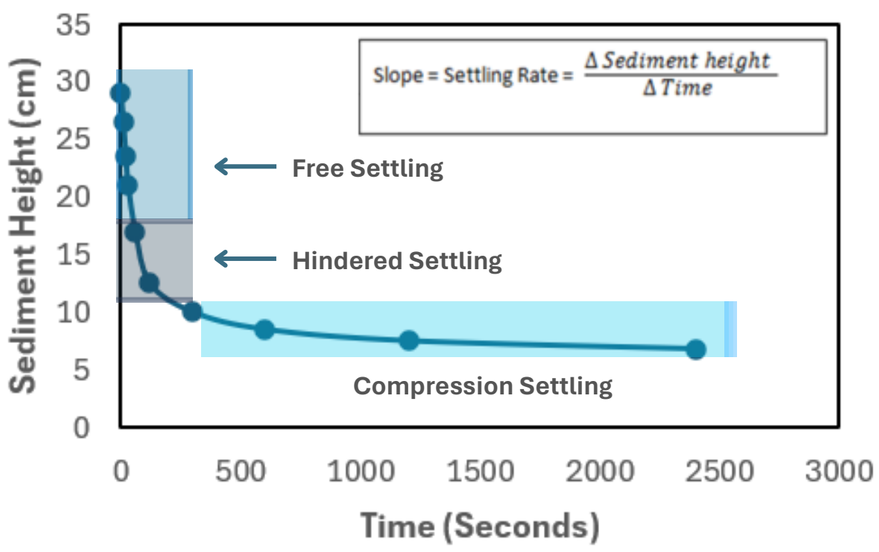
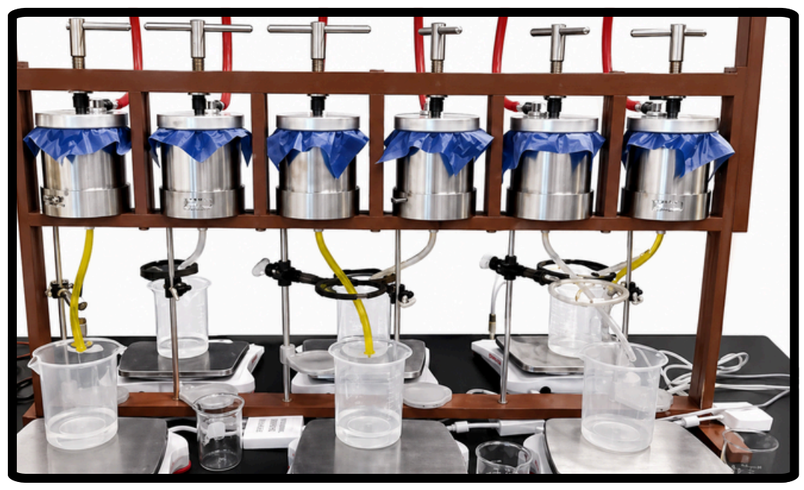
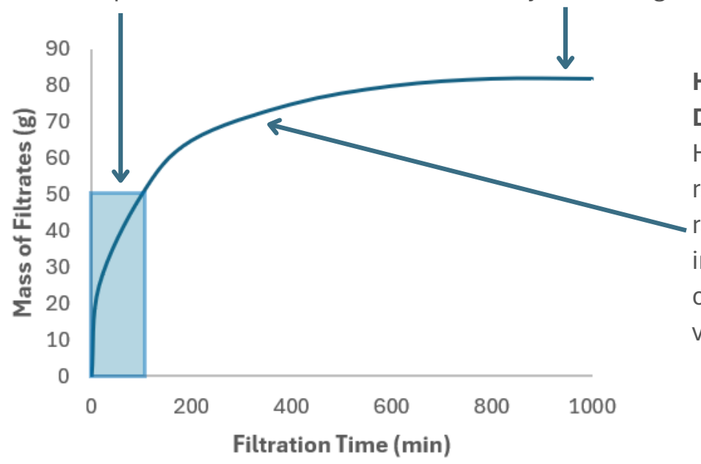


CRITERIA USED IN SELECTING REAGENTS FOR TAILINGS DEWATERING

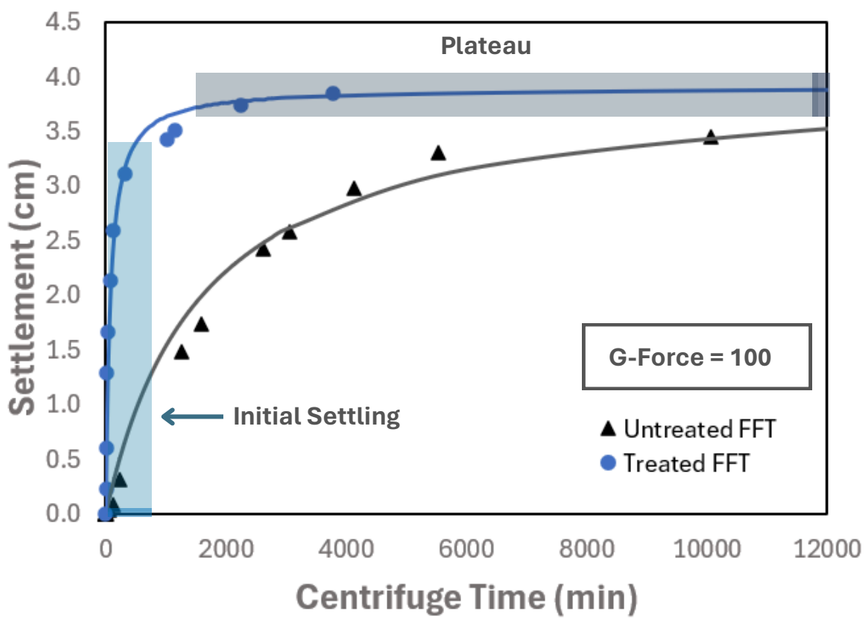
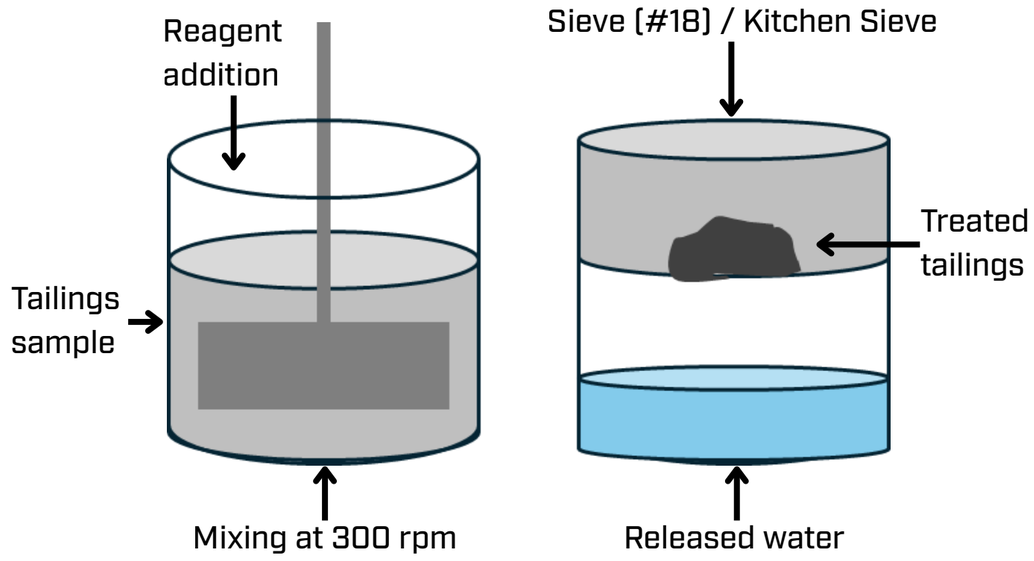
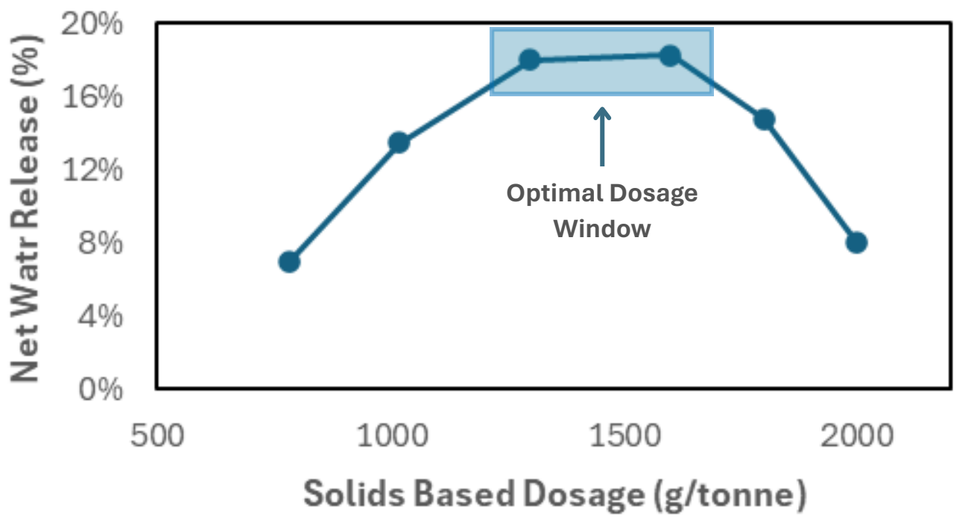
- Short-term dewatering performance
- Long-term dewatering performance
- Robustness and reliability
- Release water quality
- Ease of handling
- Capital requirements
- Cost effectiveness
- Optimal dosage range

[1] Sand/coarse are defined as particles with a diameter greater than 44 µm and fines are defined as particles having a diameter of less than 44 µm

COMMON LABORATORY TESTS FOR CHEMISTRY SCREENING

	Settling Test	Modified Filtration Test
What is it?	Measures the rate of settling of a slurry in response to a chemical addition  	Measures the total water released and dewatering rate under pressure in response to chemical addition  **Initial Dewatering:** • Volume proportional to time & pressure. Correlates with settling curves • Quantified by specific resistance to filtration equation **"Plateau"** → Hypothesis: Amount released dependent on force applied & water holding capacity of final cake • Can normalize to solids content by measuring filter cake solids  **Hindered Dewatering →** Hypothesis: rate of water release impacted by change in void ratio
Best used for?	• Screening chemicals for thickeners • Dilute feeds (< 10% solids)	• Screening of filterability • (Potentially) long-term dewatering performance
What do you measure?	• Mudline height vs. time • Look for free settling (settling rate is constant) • Clarity, colour, and total suspended solids (TSS) in supernatant • Solids content in sediment	• Filtration rate • Filtration time • Solids content of filter cake at plateau • Density of filter cake at plateau • Thickness of filter cake
What does it tell you?	• Relative settling rate • Relative clarity of supernatent	• Rate of water release impacted by change in void ratio • Specific resistance to filtration • Short-term / rapid dewatering efficiency • Long-term dewatering capacity

COMMON LABORATORY TESTS FOR CHEMISTRY SCREENING (CONTINUED)

	Centrifuge	24-Hour Net Water Release
What is it?	Measures the settlement of a slurry with time under an acceleration higher than gravity  [2]  	Measure the total water release in response to a chemical addition under gravity  
Best used for?	• Long-term dewatering performance of fine tailings samples	• In-line flocculation and beaching applications for materials forming large agglomerates
What do you measure?	• Mudline height vs. time • Contents of solids, bitumen, water, fines, and clays per desired thickness at top and bottom of sediment • Solids content at different sediments depth	• Mass of water released after 24 hours • Solids content in flocs after 24 hour drainage • Release water colour and clarity • Capillary suction time (CST) of release water
What does it tell you?	• Rate of water release • Cake solids content profiling • Consolidation behaviour over time (compressibility and hydraulic conductivity properties) [2]	• Short-term / rapid dewatering efficiency • Release water quality

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CHEMISTRY EVALUATION ROADMAP

STAGE 1:
IN-LAB KNOWLEDGE EXCHANGE

- NAIT demonstrates benchmark performance, followed by evaluation of new chemistry according to the provider's instructions
- Review results relative to benchmark for rapid troubleshooting and evaluation
- Conduct follow-up testing to collect key performance data

Outcome:

- Observational report with performance assessment and benchmark comparison
- Guidance on applications (e.g., thickeners, in-line flocculation)
- Alignment on success criteria

Flocculation

STAGE 2:
SINGLE FFT EVALUATION

- Generate dosage curves (triplicate testing) for benchmark vs. new polymer/chemistry
- Evaluate KPIs:
  - 24-hour net water release (NWR)
  - Settling, filtration, or centrifuge results
  - Water quality (color, clarity) and solids content
- Test using one FFT sample, benchmark polymer, new polymer, and coagulants (if required)

Outcome:

- Comparative assessment of dosage performance

Optional: Water Characterization

- Basic: pH, alkalinity, electrical conductivity, hardness, IC (Ion Chromatography), TSS (Total Suspended Solids), DOC (Dissolved Organic Carbon)
- Advanced: naphthenic acids via Syncrude method [3]; heavy metals via ICP (Inductively Coupled Plasma); hydrocarbons such as F1-F3, BTEX (Benzene, Toluene, Ethylbenzene, Xylene), and phenols via GC (Gas Chromatography)

Optional Outcome:

- Comparative water chemistry assessment

Settling Tests

STAGE 3:
FULL FLOCULATION EVALUATION

- Develop dosage curves (triplicate testing) across multiple FFT samples
- Apply dewatering methods from Stage 2
- Evaluate:
  - Water quality (colour, clarity)
  - Solids content in separated solids
- Assess polymer hydration at room and low temperature

Outcome:

- Comparative performance across multiple FFTs
- Evaluation of robustness and sensitivity to feed variability

Net Water Release

HOW TO STAY CONNECTED & INFORMED

- To learn more about tailings treatment and polymer evaluation, or to explore other projects, resources, and technical insights, visit the Centre for Energy and Environmental Sustainability website or contact us at CEES@nait.ca.

REFERENCES

[1] Alberta Energy Regulator, Directive 085: Fluid Tailings Management for Oil Sands Mining Projects. Calgary, AB, Canada: Alberta Energy Regulator, 2022.

[2] M. Ahmed, N. A. Beier, and H. Kaminsky, "Evaluation of the self-weight consolidation of clay-rich high water content slurries in a benchtop centrifuge," Geotechnics, vol. 5, no. 1, p. 18, 2025, doi: 10.3390/geotechnics5010018.

[3] M. J. Ripmeester and D. A. Duford, "Method for routine 'naphthenic acids fraction compounds' determination in oil sands process-affected water by liquid-liquid extraction in dichloromethane and Fourier-transform infrared spectroscopy," Chemosphere, vol. 233, pp. 687–696, 2019, doi: 10.1016/j.chemosphere.2019.05.222.