A case for elimination of tailings ponds through in-line treatment using a low cost, flocculent free approach: results from two on-site trials

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Introduction

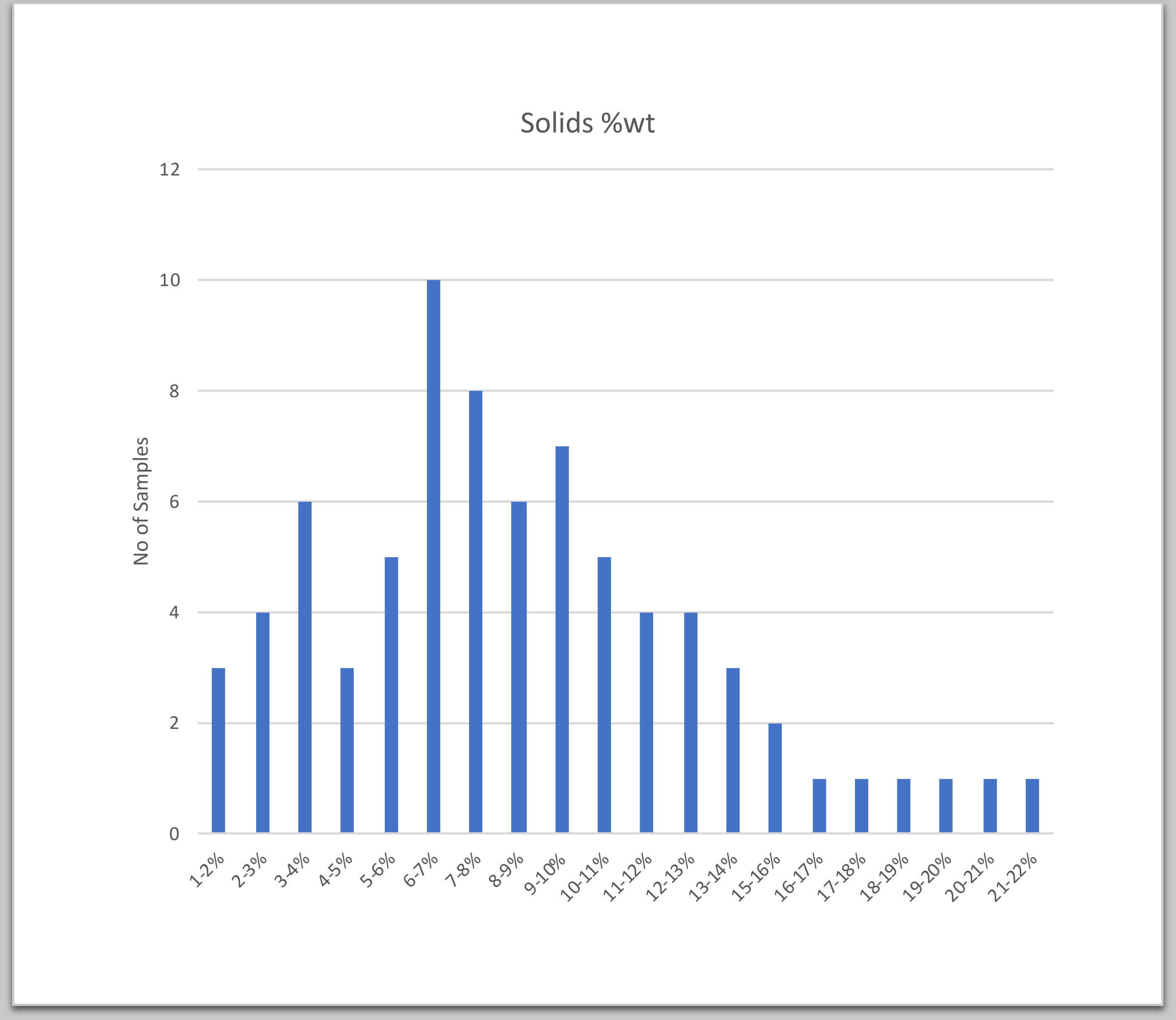
- In-line treatment – why do it
  - Heat
  - Liability
  - Resource Recovery (bitumen, water)
  - Social License
- How we approached it
  - Oil removal-because it is hard on treatment processes and it has value
  - Heavy solids – remove settleable solids (clarifier, centrifuge, cyclone)
  - Ultrafiltration – remove enough to facilitate (passive) treatment and release to the environment possible (because reuse is already easy).

First a comment on effort

- When we initiated the centrifuge project it was with a research budget discretionary fund (Do they exist anymore?).
- The cost of the project was 3x higher than originally expected. Welcome to the oil sands but this was largely a data issue.
- We learned a great deal, NOTHING beats on site pilot work.
- Most of the participants have since moved on, the learnings are poorly documented history, perhaps lost history in the tailings world.
    - The centripetal components of this presentation are reconstructed from a fraction of the total data that was collected.
- The water treatment piece had much wider participation but it too appears to have been forgotten.

Fresh Tailings

- Combination of:
  - Froth flotation tails – primary target fines dominated.
  - Secondary extraction tails – sand contribution.
  - Water cap recycle water – movement due to storage balancing.



Oil Removal

- We deployed a standard horizontal mechanically induced flotation system (Wemco).
- Foaming was an issue. Gaskets had to be managed and ports locked down
- Solids accumulation in cells was problematic – large efficiency losses and clean-out downtime.
- Surprising oil recovery possible (OK nothing for a mine but BIG for an ESC).

Heavy Solids

- Mud tank used as buffer tank with two mud guns.
  - Solids accumulation in mud tank was horrendous.
    - Required confined space entry and steam service for maintenance.
- Hydrocyclone shaker skid (desilter)
  - Never achieved the theoretical cut
  - Screens blinded immediately. Cold weather a big issue.
  - Still believe this is a technology worth investigating.

Centrifuge – Brute force has its benefits

Table 3: Trial conditions.

Centrifuge Parameters			
Pump Speed (rmp)	900	1200	1400
Back Drive %	15	25	38
Bowl Speed (rpm)	2200	2400	2800
Chemistry Trials			
No chemistry			
Polymer (g/t)	500	750	1000
Alum (g/t)	500	750	1000
Polymer & Alum (g/t)	500	750	1000
Gypsum (g/t)	500	750	1000
Polymer & Gypsum (g/t)	500	750	1000

- Coagulants alum and gypsum used
- Flocculant A3338 used
- Measurement challenges
  - CST, % solids, vane shear
- Most important performance paramters were:
  - Solids content of feed
  - Coarse content of feed
  - Gypsum over flocculant
    - Gypsum solids that developed better strength and released water but lower capture
    - Flocculant – better solids capture but marshmallows with wetter solids.

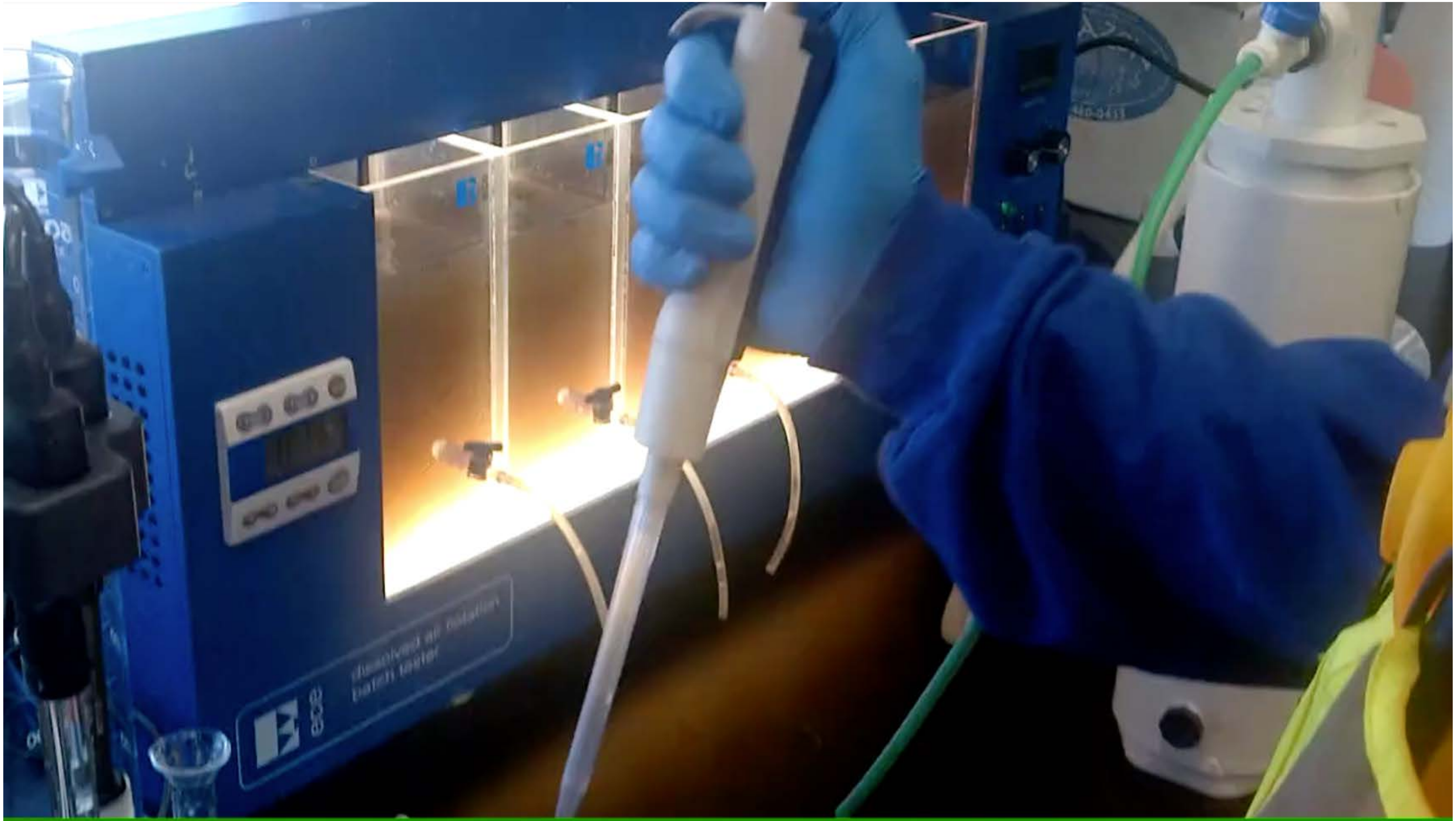
Water Cap – Processing stable ultrafine solids

Parameter	Units	Average	Max
pH	SU	8.29	8.39
Total Alkalinity	mg/L as CaCO3	725	780
TSS	mg/L	359	880
Turbidity	NTU	489	1000
Conductivity	µS/cm	2988	3200
TDS	mg/L	2094	2500
Total Sodium	mg/L	631	700
Chloride	mg/L	450	520
Bicarbonate	mg/L	876	930
Total Hardness	mg/L as CaCO3	47	56
TOC	mg/L	47	69
Oil & Grease	mg/L	25	32
Naphthenic Acids	mg/L	54	68
COD	mg/L	425	530

- CNRL initiated a technology search for pre-treatment to a potential RO water treatment plant.
- Global search, reduced to 12 technologies, 3 selected for piloting
- 2 eventually trialed on site.
- Our pilot system consisted of flotation and ultrafiltration.

Froth Flotation

- High Intensity Froth Flotation (HiFF).
  - Uses a highly charged (anionic) surfactant and air to generate froth.
  - The charged bubble surface causes EDL collapse and attachement.
  - Larger bubble sizes to increase rise rate.
  - Can work with any flotation system.
- 98.6% turbidity removal in a simple step
  - Very low cost
  - Simple implementation


dissolved air flotation
batch tester

Ultrafiltration

- Uses same principle of EDL collapse using a highly charged replaceable skin layer.
  - Overcomes the issue of membrane fouling
  - >10x the efficiency of standard ultrafiltration.
  - Dead-end, no crossflow required.
- Reduced turbidity to 0.2 NTU
- Subsequent trials with higher concentration brines
- Reduction in Si by 99%

Table 5: Ultrafiltration of 3 high mineral content brines from the Ft McMurray area. Raw is the feed water and Perm is the permeate after ultrafiltration.

Scale Parameter	EBD1 Raw	EBD1 Perm	EBD2 Raw	EBD2 Perm	OTSG Raw	OTSG Perm
Total Silicon (mg/L)	1641	33	9200	71	120	22
Total Barium (mg/L)	14	4.9	5.5	0.6	32	<0.1
Total Strontium (mg/L)	67	34	13	5	0.21	<0.2
Fe-Dis (mg/L)	10	ND	<6	<0.6	<0.6	<0.6
Ca-Dis (mg/L)	1387	637	180	150	100	46
Mg-Dis (mg/L)	115	33	20	4.1	20	2
TOC (mg/L)			4800	3550	660	180
Turbidity (NTU)					8.5	2.2