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TITANIUM CORPORATION

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# Vapour-Liquid Equilibria and Solvent Recovery from Oil Sands Froth Treatment Tailings Streams

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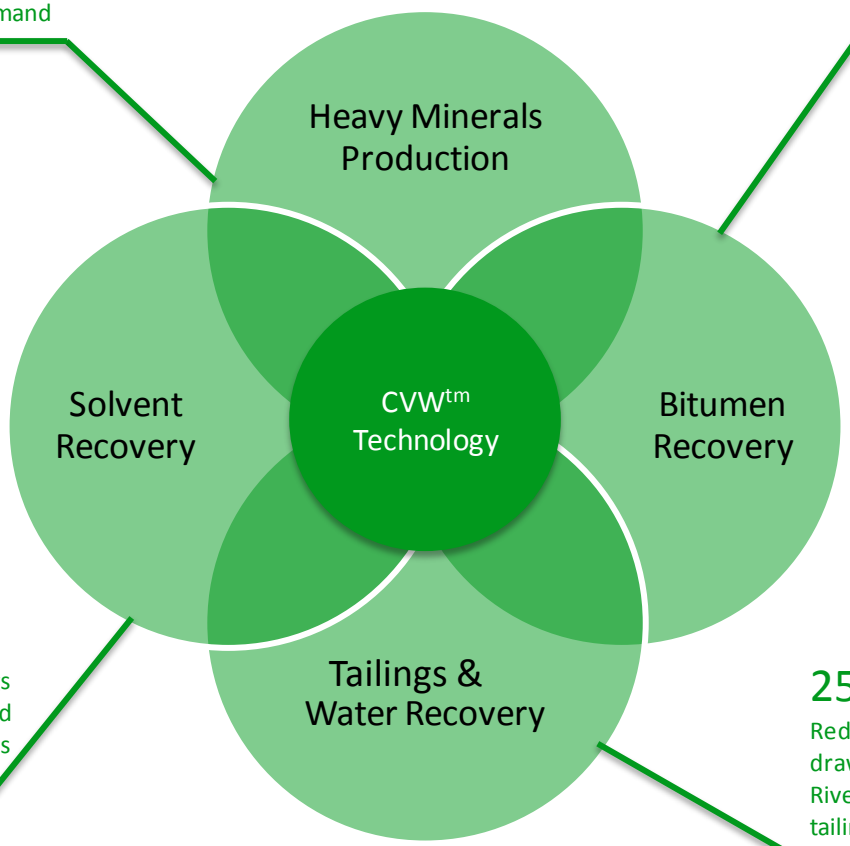
Creating Value from Waste™

Paper 550

# Creating Value from Waste™

Development of a
new source
of heavy minerals to meet growing world demand

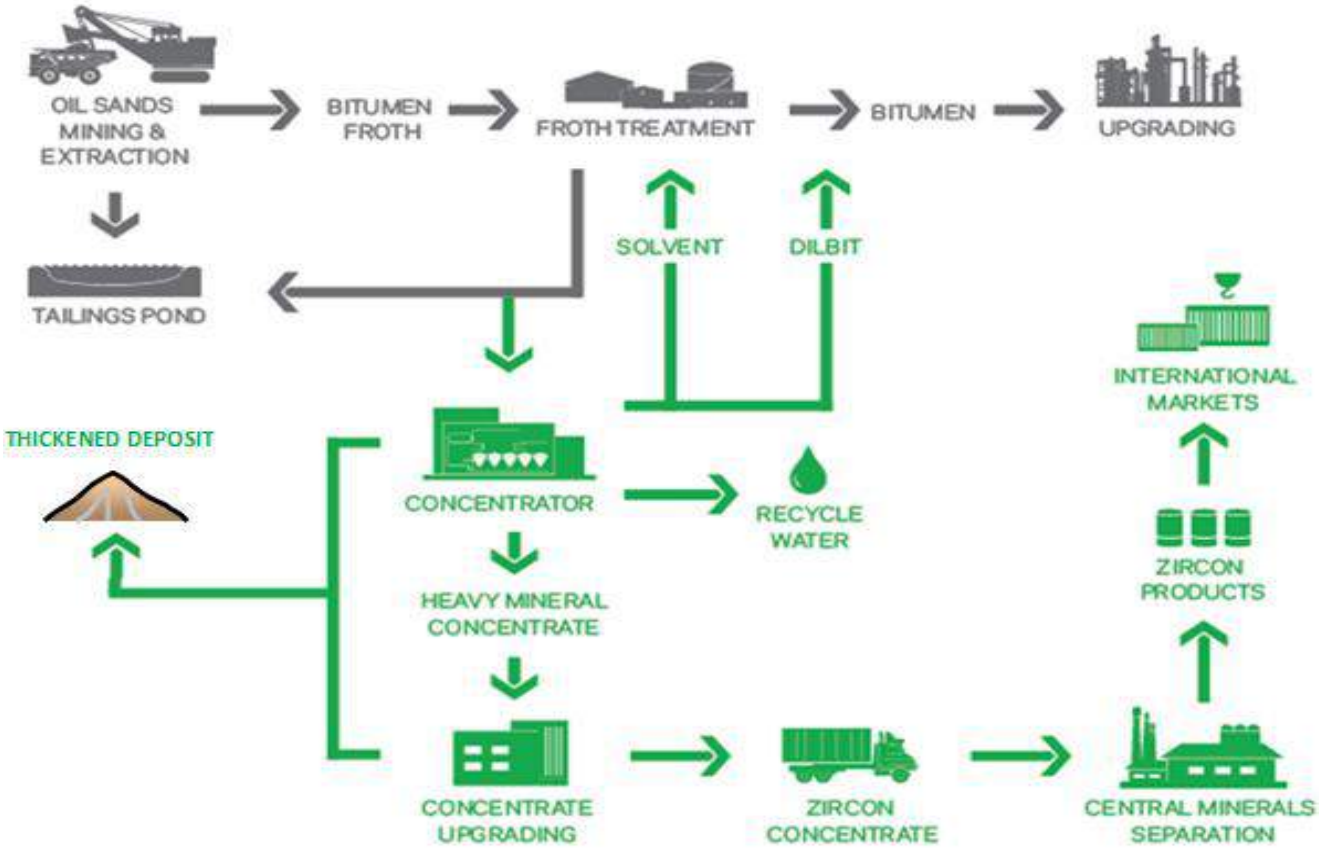



2%
Increase in recoveries of processable bitumen for integration with existing upgrading infrastructure

75%
Reduction of tailings solvent losses with related GHG and VOC emissions reduction

25%
Reduction of fresh water draw from the Athabasca River and thickened tailings per Directove 74

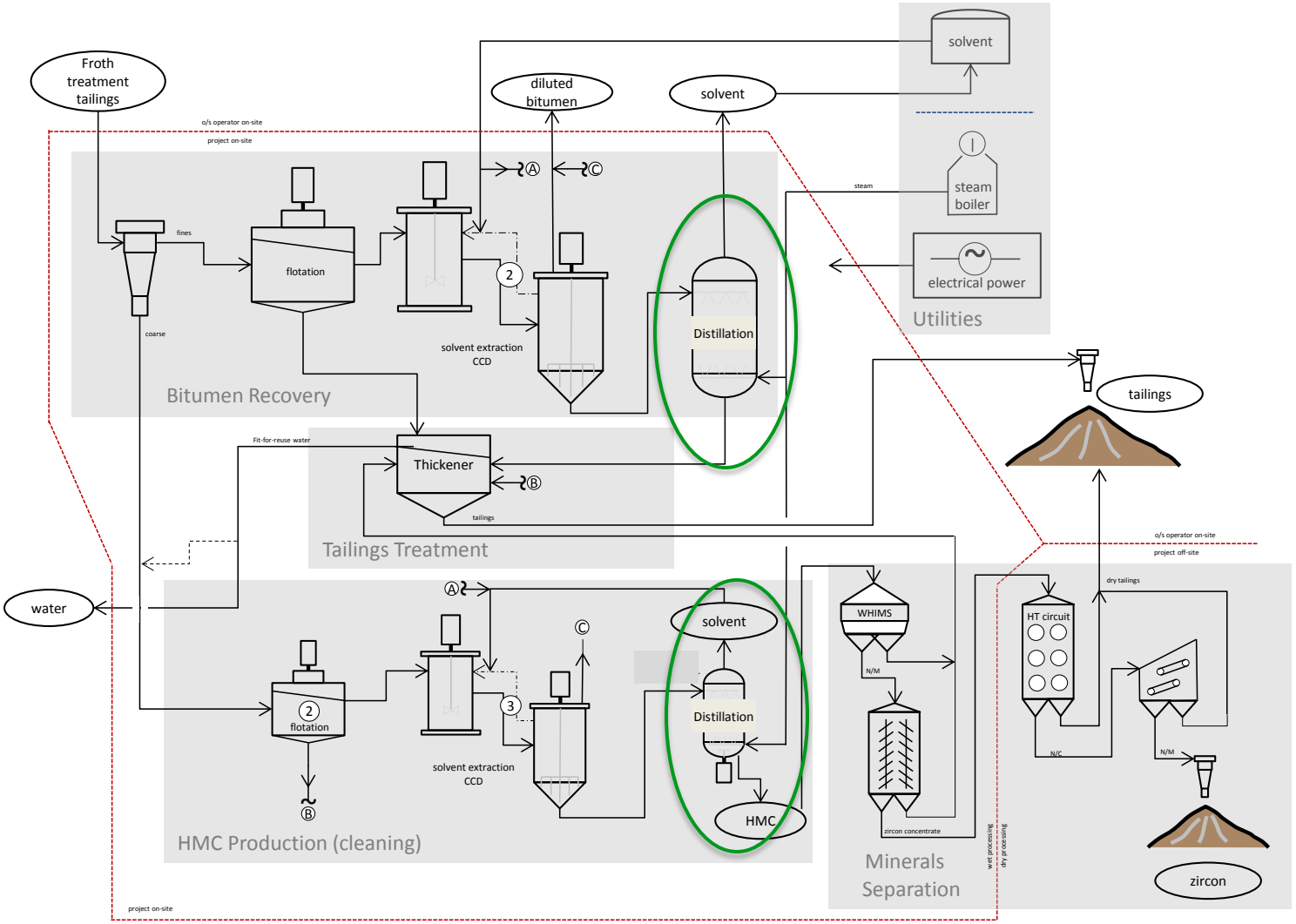
# Titanium's CVW™ technology is designed to intercept FTT before discharge to ponds and recover valuable minerals, lost bitumen, solvents and water




- Napththa contributes directly to fugitive methane, VOC emissions from tailings ponds
- Process naphtha removed from raffinates (AER mandate ~4 bbl/kbbl dry bitumen)
- Results in current losses of up to 1.4 Mbbls, and fugitive releases of 1 Mt GHGe and 40 kt VOC

# Technologies Overview

## Process flow diagram




- Raffinates naphtha recovery to offer environmental benefits and enable minerals recovery

# Tailings Solvent Recovery

## R&D program overview

### Phase 1: laboratory-scale thermodynamic experiments

- Determine the vapour-liquid equilibrium of tailings over a range of
  - Operating temperatures
  - Contained solvent content
  - TIC process raffinates from naphtha-based tailings

### Phase 2: bench-scale kinetic experiments

- Impact of residence time and conditioning intensity on separation performance
- Settling rate/consolidation rate considerations

### Phase 3: live demonstration pilot

- Optimize design criteria
- Validate performance at large scale
- Determine operating envelope
- Identify scaling issues

# Tailings Solvent Recovery

## Phase 1 – VLE experiments

### Objective

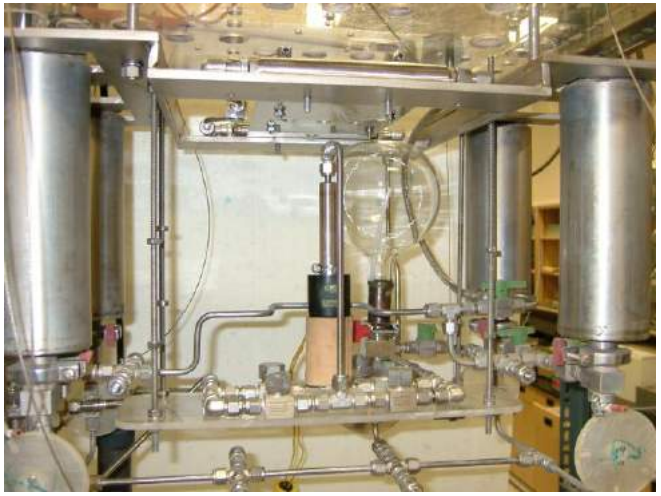
- To determine the equilibrium thermodynamics governing phase separation in process raffinates

### Overview

- Partnered with D-Y Peng at University of Saskatchewan
- Experiments to include a range of temperatures under different feed and operating conditions
- 96 experimental runs tested

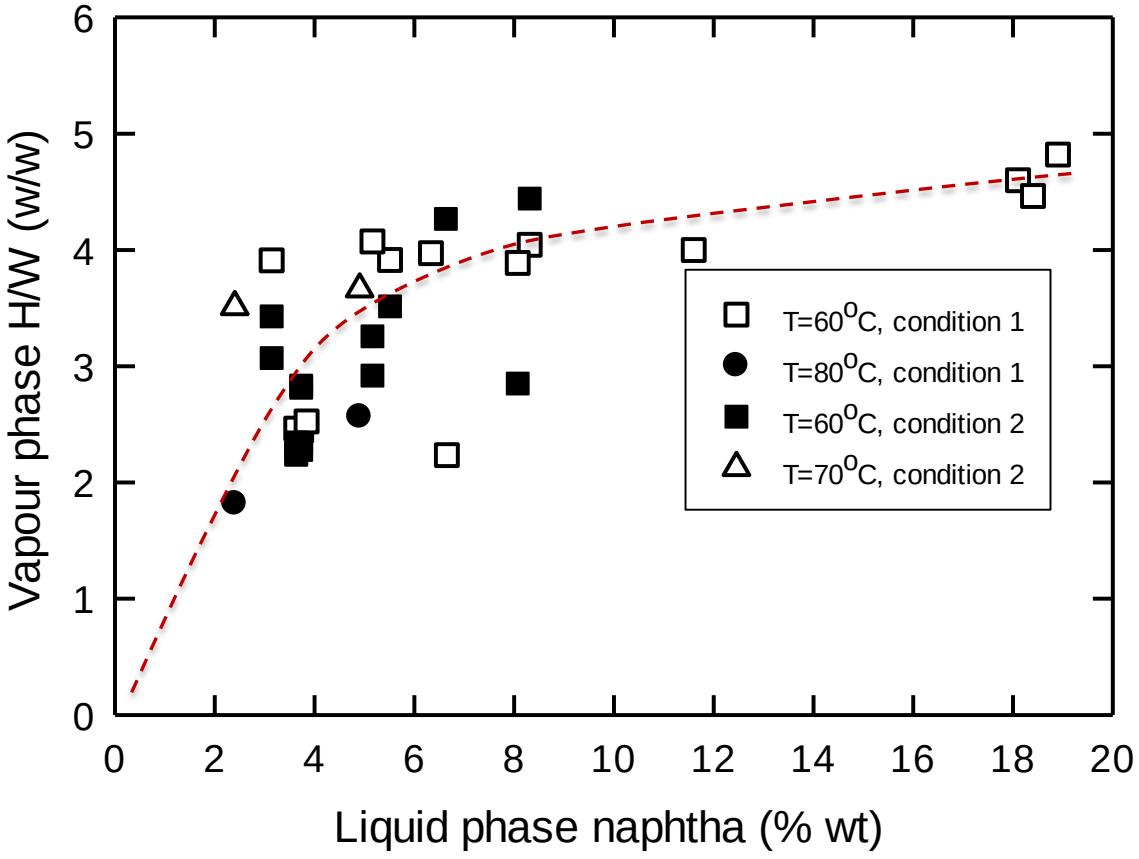
# Tailings Solvent Recovery

## Phase 1 – experimental equipment



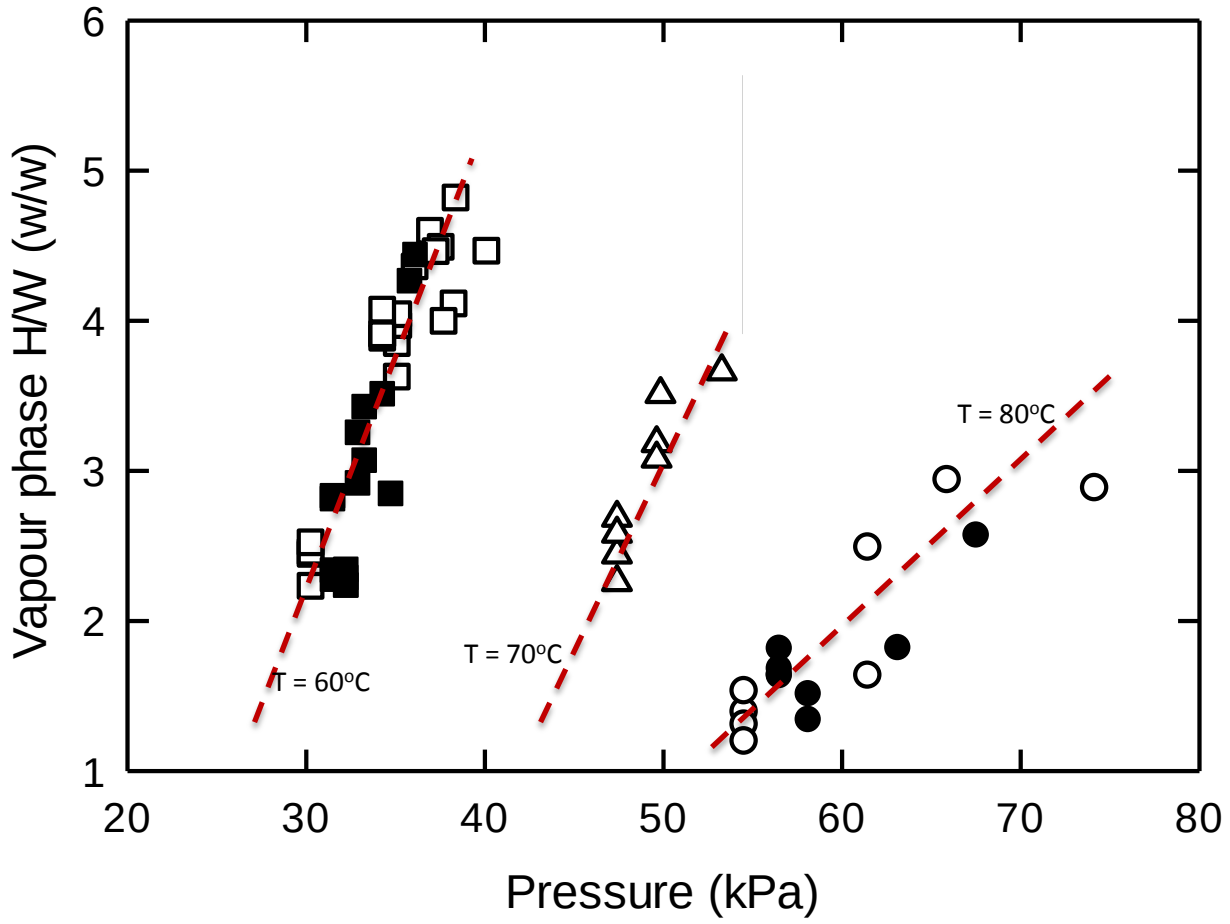
# Tailings Solvent Recovery

## Phase 1 – vapour liquid equilibria



# Tailings Solvent Recovery

## Phase 1 – vapour liquid equilibria

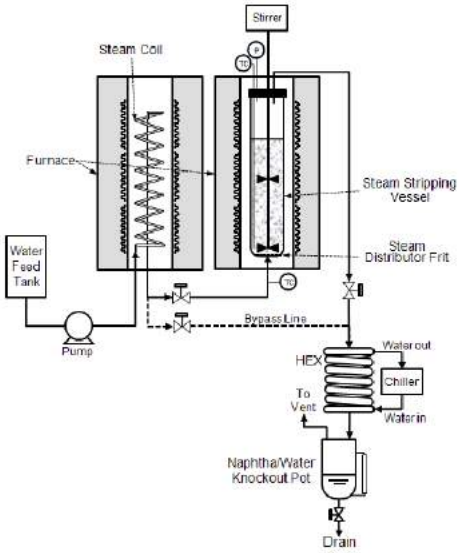


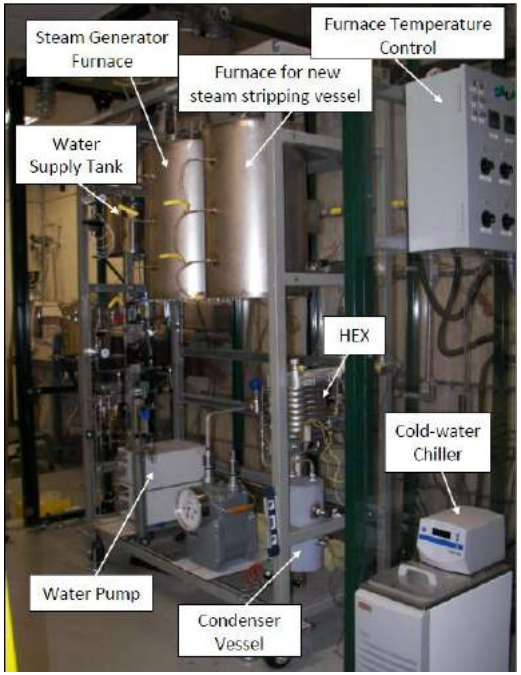
# Tailings Solvent Recovery

## Phase 2 – kinetics experiments

Objectives

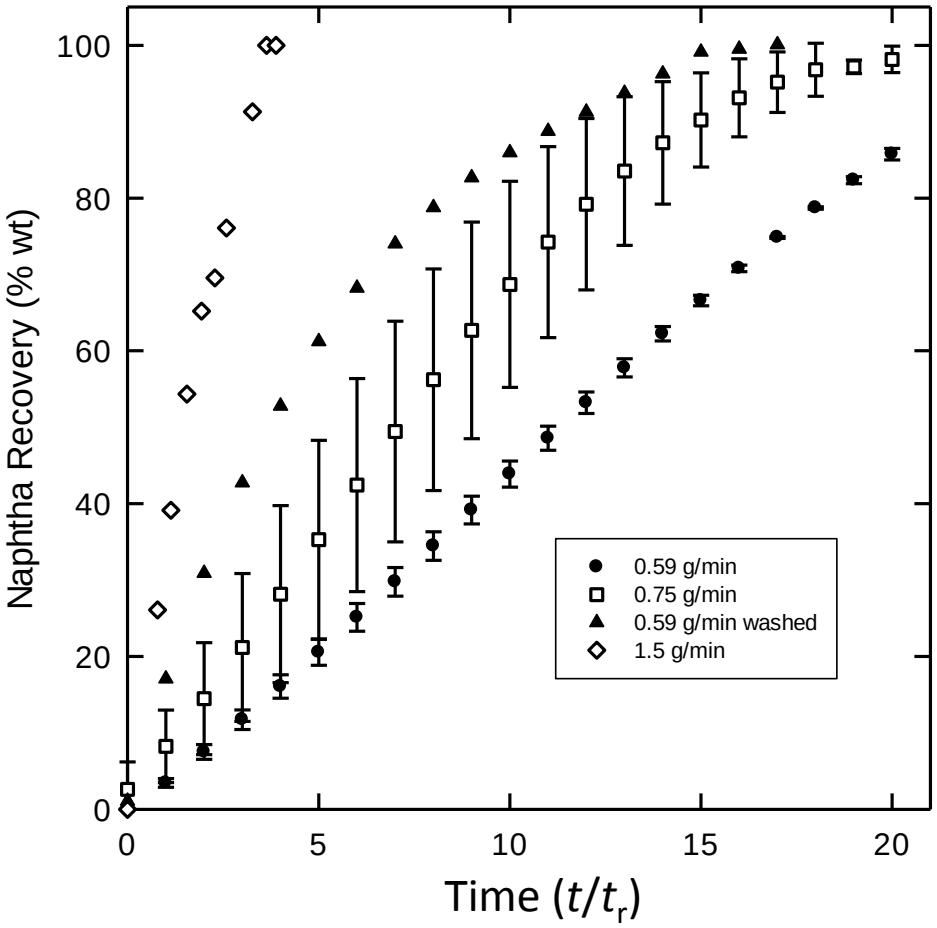
- To identify unit operations suitable for tailings solvent recovery
- To determine the conditioning intensity criteria required to achieve/approach thermodynamic equilibrium
- Experiments to include a range of operating conditions including
  - Heat addition rate
  - Liquid hold-up
  - Conditioning intensity



# Tailings Solvent Recovery

## Phase 2 – results



# Demonstration Plants

## Phase 3 – tailings solvent recovery validation

### Objectives

- $19 million operator-specific, demonstration pilot at CanmetENERGY Froth Treatment Pilot
- Integrated operation of technologies to performance targets, including tailings management
- optimization of CAPEX/OPEX, design scaling (Tier 1 EPCM)
- 10 kg/min nominal rate for NFT tailings; 1 kg/min for PFT tailings
- 1000 material balances; 50,000 analytical samples (Maxxam Analytics)

### Consortium Partners

- Suncor, Syncrude, CNRL (tailings provision; expertise/review)
- Sustainable Development Technology Canada (SDTC; $6.4M)
- Alberta Energy ($3.5M)
- Sojitz Corporation (minerals markets)

### Independent Reviews

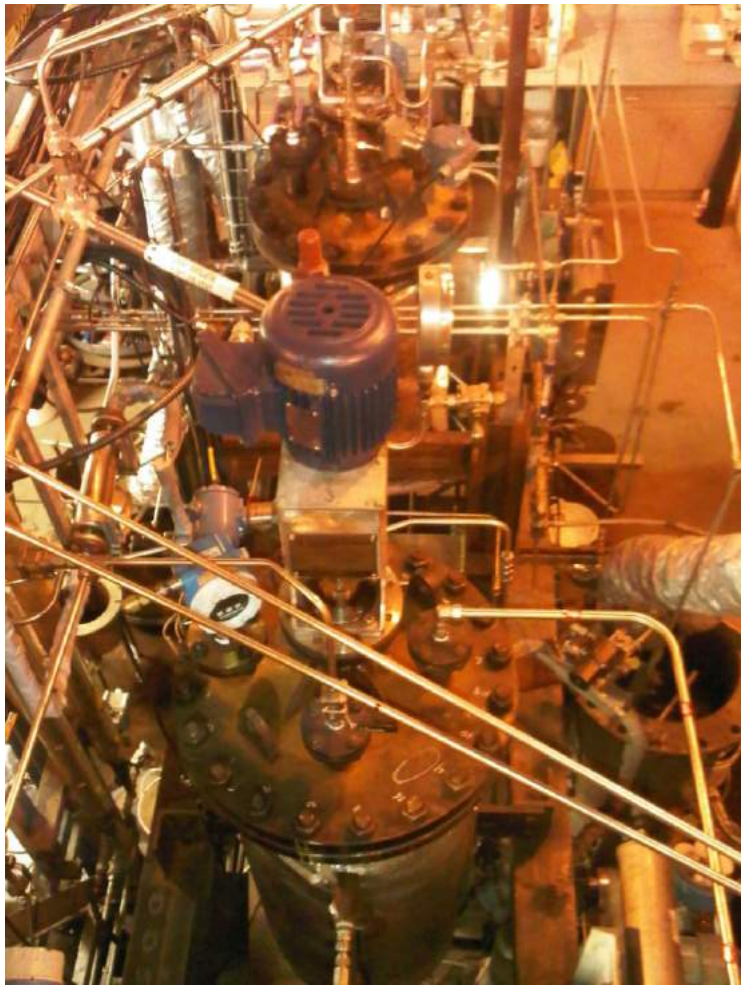
- COSIA – Tailings Technology Roadmap; priority ranking #16
- Canadian Council of Academies 2015
- Operators: Syncrude, CNRL, Suncor, Iluka Resources, …
- Consultants: CanmetENERGY , Jacobs Consultancy, Pembina Institute…


Titanium's Pilot at
CanmetENERGY


Titanium’s Pilot at
CanmetENERGY

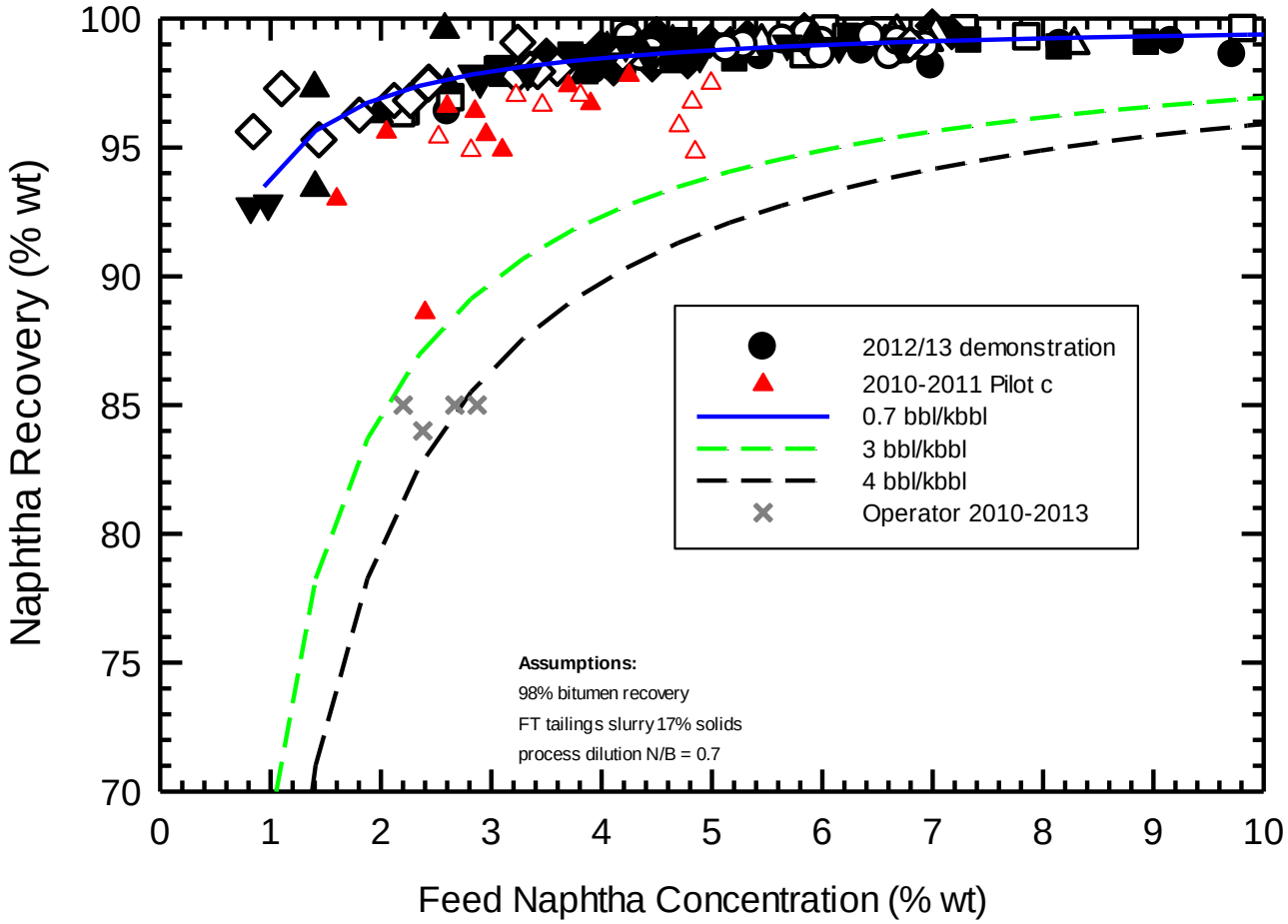
# Demonstration Plants

## Phase 3 – demonstration tailings steam stripping units



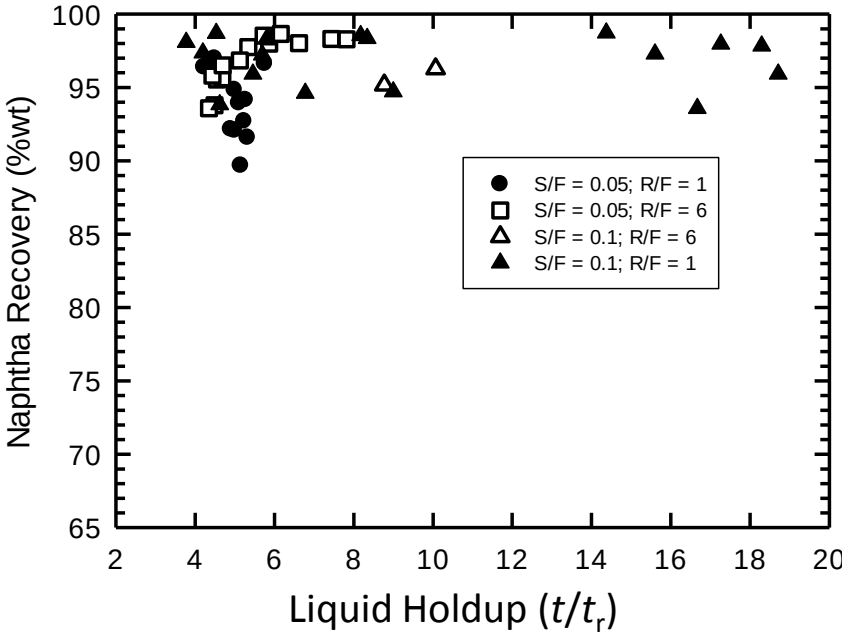
# Demonstration Plants

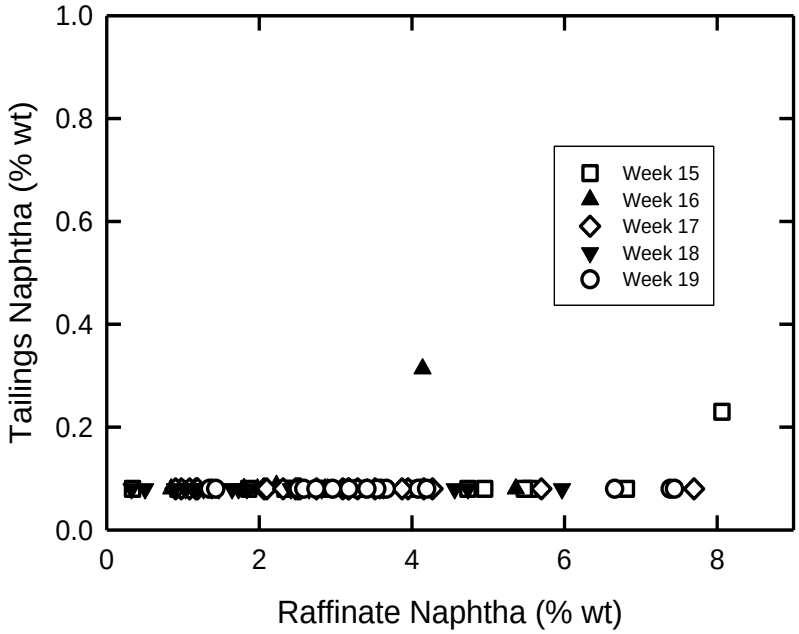
## Phase 3 – tailings distillation results



# Demonstration Plants

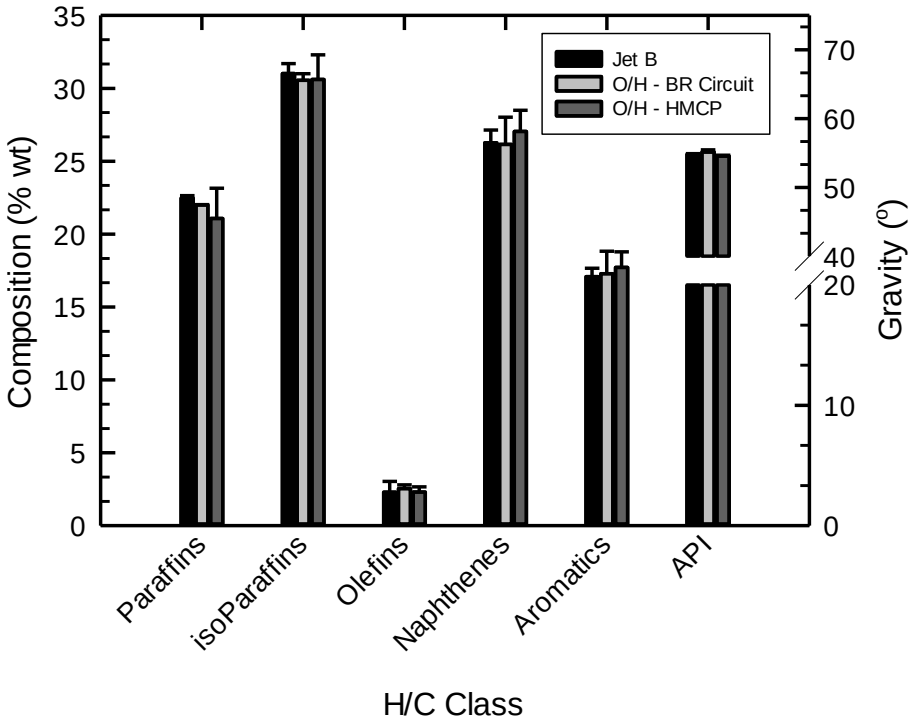
## Phase 3 – tailings distillation results

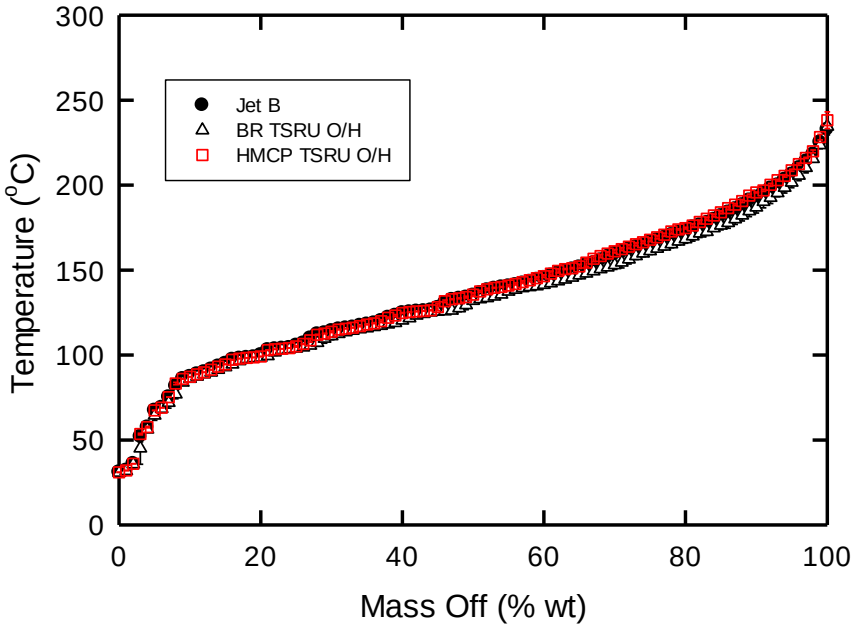


# Demonstration Plants

## Phase 3 – recovered solvent quality



# Summary

- Detailed VLE experimentation enabled optimized thermodynamics in design of tailings distillation unit
- Kinetic experiments enabled understandings of mass transfer conditions required to reach VLE
- Titanium's CVW™ tailings distillation unit validated at demonstration pilot
  - Reduces naphtha loss to tailings by up to 80%
  - Achieves residual losses of ~0.7 bbl/kbbl (compared to current ~4 bbl/kbbl)
  - Can prevent the release of 3-5 Mt/a of GHG and 50 kt of VOC from tailings ponds annually by 2030