New Oil Sands Technology to Meet the Challenges of Climate Change and Tailings Management

Titanium Corporation
Emerging Environmental Landscape

2009 Alberta D74 Tailings Management

2009 - Tailings Pond Deposition/Settling
Mature Fine Tailings (MFT)
OS tailings hydrocarbon losses

2015 UN Climate Conference

2015 Alberta Climate Change Leadership Plan

2015 Canadian Council of Academies Tailings Report

2013 COSIA OS Tailings Bitumen Impacts

2012 COSIA OS Tailings Management Roadmap

2016 Alberta D85 Revised Tailings Management

2016 Environment Canada Secondary Organic Aerosols

2016 Alberta Climate Change Leadership Plan

Integrated approach towards sustainable remediation of OS tailings:
Accelerated Reclamation
GHG/VOC/SOA Emissions
Water Quality and Reuse

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Tailings Pond Deposition/Settling Mature Fine Tailings (MFT)
OS tailings hydrocarbon losses
Integrated approach towards sustainable remediation of OS tailings

2015
Alberta Climate Change Leadership Plan
Reduce methane emissions by 45% or 12 Mt/a

2015
Canadian Council of Academies OS Tailings Report
Process ‘toxic’ froth treatment tailings separately

2016
Alberta Energy Regulator Directive 85
“Ready to Reclaim” tailings deposition
Minimize environmental effect of deposition…froth treatment tailings, gas emissions...

Fugitive GHG/methane/VOC emissions and other challenges from Oil Sands Tailings and Ponds


**Air Emissions**
A = Rapid volatization of VOCs as hot tailings solvents are discharged into the atmosphere
B = VOCs volatized from oily films at pond surface (slicks), SOA precursors
C = Anaerobic fermentation of solvents into methane (methanogenesis)
D = Compound cycling results in fixed carbon (bitumen/solvent) trapped in tailings

**Tailings Management**
Mature Fine Tailings (MFT) – non-segregating dispersion of fines and clays; trapped bitumen further impedes reclamation efforts (centrifugation, thin lift deposition)

**Emerging Issues**
Concentration and deposition of radioactive solids (Canadian NORM management) and pyrite (acid rock drainage)

**Water Quality**
Dispersed fine particles and residual hydrocarbons limit reuse applications
Titanium’s CVW™ technology focuses on remediating oil sands froth treatment tailings (FTT)

**Step 1: Mining**
- Eight oil sands individual mines
- Among the world’s largest mines
- Truck and shovel mining to 100m
- Ore contains average 10% bitumen

**Step 2: Extraction**
- 15 barrels of water used per 1 barrel of bitumen
- 85-90% of this water is recycled
- Flotation and settling processes produce bitumen froth
- Extraction tailings comprised of water, sand and bitumen

**Step 3: Froth Treatment**
- Hydrocarbon solvent is added to bitumen froth
- Gravity separators reject sand/water
- Bitumen sent to up-graders/pipelines
- Tailings are comprised of water, bitumen, solvent and sand/fines which are discharged to ponds
- Regulations allow losses of 4 barrels of solvent per 1,000 barrels of bitumen

**Tailings Ponds**
- 22 active tailings ponds, area of 220 sq km, 54,363 acres
- Tailings ponds contain 975 million m³ of fine fluid tailings
- 90-94% from extraction tailings and 6-10% from FTT
- Largest source of fugitive GHG and VOC emissions
- Radioactive minerals from FTT are concentrated in ponds
- Process heat in FTT is dissipated to environment
Froth treatment tailings are environmentally and economically significant (although volumes are much smaller than extraction tailings)

- FTT are a mixture of water, sand, fine clays, hydrocarbons, representing 6-10% of total tailings volumes
- FTT contain most recoverable economic value
  - 100% of solvent losses
  - 95% of heavy minerals
  - 25% of bitumen losses
- FTT tailings also contain the most environmentally damaging elements
  - 100% of methane producing solvents, VOC and SOA source
  - 95% of radioactives
Titanium’s CVW™ technology is designed to intercept FTT before discharge to ponds and recover valuable minerals, lost bitumen, solvents and water.
Titanium’s CVW™ is a SDTC portfolio technology, demonstrated at Natural Resources Canada’s CanmetENERGY oil sands commercial pilot facilities in Devon, Alberta with the support of government and a consortium of oil sands firms.

- 2010-2013 integrated demo
- Industry-standard scale
- Validated by stakeholders
- 13 patents in IP portfolio
Titanium’s CVW™ end-to-end tailings solution for froth treatment tailings offers potential to avoid tailings ponds completely, improving tailings management and reducing costs.

Tailings bitumen and solvent recovered using Titanium’s patented CVW™ technologies, deliver GHGe methane reductions (up to 1 Mt/yr/site) & VOC emissions reductions (10kt/yr/site).

Minerals exhibiting radioactivity are segregated into minerals concentrates and transported off-site, leading to 80% reduction in radioactivity in beached sands.

Thickener operates at reduced polymer dosages (by up to 67%) and enhanced performance allows for heat recovery and integration, further offsetting GHG emissions (~0.1 Mt/yr/site). Fit-for-reuse water recycled to process applications and/or low grade utility purposes to offset fresh water intake from Athabasca River.

Tailings dewater efficiently to exceed 5 kPa strength in less than 1 year; accelerate trafficability and reduce fines loading to tailings pond.

Fugitive GHG Emissions Sources

- Froth treatment tailings are the largest source of fugitive GHG emissions at oil sands site
- Tailings pond GHG emissions can represent up to 90% of fugitive losses; 10% site-wide emissions
- Tailings pond methane emissions result from microbial fermentation of FTT naphtha

Fugitive GHG Emissions Abatement

- Titanium’s CVW™ removes 80% of tailings pond methane emissions; 50-70% of total fugitives
- Further abatement possible (up to 95%) as tailings directed to integrated dry reclamation deposition


Based on mining production reported by “Crude Oil: Forecast, markets and Transportation”, Canadian Association of Petroleum Producers, June 2016.
VOC and SOA abatement

- Froth treatment tailings are the largest source of fugitive VOC emissions at oil sands site
- Titanium’s tailings solvent recovery technology reduces pond deposition of hot naphtha from FTT
- CVW™ reduces oil sands VOC emissions by over 70% site-wide
- Recovery of semi- and intermediate volatility hydrocarbons from FTT contributes to SOA abatement


Based on mining production reported by “Crude Oil: Forecast, markets and Transportation”, Canadian Association of Petroleum Producers, June 2016.
Froth Treatment Tailings Management

- Froth treatment tailings have a relatively high amount of fines material
- Further complicated by relatively high amounts of bitumen and solvent
- Titanium processing classifies solids into a fines-enriched tailings; coarse stream to HM process
- CVW efficiently recovers hydrocarbons; tailings dewatering with high fines capture
Enhanced Tailings Management

- Consolidation of contained fine solids enhanced due to low concentrations of bitumen

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- Achieve solids concentrations of 75% within one year, exceeding mandated depositional strength
Consolidation at low flocculant dosage

- Excellent thin lift response at polymer dosing of less than 400 ppmw (vs industry avg ~1000 ppmw)
Summary

• Emerging sustainable landscape for oil sands mining – Directive 85 calls for a holistic approach to reclamation that addresses environmental performance on a number of dimensions and identifies froth treatment tailings as higher risk

• Froth treatment tailings are a significant source of environmental challenges including fugitive methane emissions, VOC and SOA emissions...

• Titanium’s integrated CVW™ process offers an end-to-end tailings management solution that can avoid pond deposition, abates air emissions issues and improves water usage efficiency

• CVW™ has positive economics: Recovered bitumen and solvent of sufficient quality for SCO feedstock; valuable heavy minerals suitable for global markets