CVW
CLEANTECH

Process and Technology Overview

JULY 2023

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Glossary of Terms

AACE: Association for the Advancement of Cost Engineering
AER: Alberta Energy Regulator
API: American Petroleum Institute
ASTM: American Society for Testing and Materials
Base Mine: Suncor Energy oil sands mine (1967)
CAC: Critical Air Contaminants
Canadian Natural: Canadian Natural Resources Ltd.
CAPP: Canadian Association of Petroleum Producers
CEP: Construction Execution Plan
CNUL: Canadian Natural Upgrading Ltd.
COSIA: Canada's Oil Sands Innovation Alliance
CP: Concentrator Plant
CVW: CVW CleanTech Inc.
CVW™: CVW CleanTech's froth treatment tailings remediation process technology
DAB: Partially de-asphalted bitumen
EcoBase: CVW CleanTech's 'hydrocarbon only' processing option
EcoFlex: CVW CleanTech's phased approach to project development
EcoMax: CVW CleanTech's full hydrocarbon and minerals project
FEED: Front End Engineering Design
FFT: Fluid Fine Tailings
FTT: Froth Treatment Tailings
GHG: greenhouse gases
GREET1: Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies, full lifecycle model - Model 1
HAZOP: Hazard and Operability Analysis
HiTi: mineral product with high titanium mineral values
HMC: Heavy Mineral Concentrate
IHC Robbins: IHC Robbins Pty Ltd.
Imperial Oil: Imperial Oil Ltd.
Integrated Demonstration Pilot: CVW CleanTech's demonstration pilot at CanmetENERGY
JPM: Jack Pine Mine
MCRT: Microcarbon Residue Test
MRM: Muskeg River Mine
MSP: Mineral Separation Plant
NFT: Naphtha-based froth treatment
NLI: Naphtha Loss Intensity
NORM: Naturally Ocurring Radioactive Material
NRU: Naphtha Recovery Unit
P&ID: Piping and Instrumentation Diagram
PFT: Paraffinic Froth Treatment
RDPA-1: Regulations Designated Physical Activities, Schedule 1
SCO: Synthetic Crude Oil
SDTC: Sustainable Development Technology Canada
SOA: Secondary Organic Aerosol
Suncor: Suncor Energy Inc.
Syncrude: Syncrude Canada Ltd.
TAN: Total Acid Number
TDU: Tailings Distillation Unit
Teck Project: Frontier Oil Sands Mine Project
THM: Total Heavy Mineral
TIER: Alberta's Technology Innovation Emission Reduction regulation
TIMA-X: Tescan Integrated Mineral Analyzer
TRL: Technology Readiness Level
TSRU: Tailings Solvent Recovery Unit
TZMI: TZ Minerals International Pty
VHM: Valuable Heavy Mineral
VOC: Volatile Organic Compound
VRU: Vapour Recovery Unit
XRF: x-ray flourescence
ZIA: Zircon Industry Association

Glossary of Chemical Notation and Units

bbl	barrel
bbl/d	barrels per day
kbbl/d	thousand barrels per day
MMbbl/d	million barrels per day
MMbbl/a	million barrels per annum
MJ/bbl	megajoules per barrel
^{o}C	degrees Celsius
CAD or C$	Canadian dollar
C$M	Canadian dollars in millions
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CO_2e/bbl	carbon dioxide equivalent per barrel of oil
CO_2e/GJ	carbon dioxide equivalent per gigajoules
CO_2e/kg	carbon dioxide equivalent per kilogram
CO_2e/MWh	carbon dioxide equivalent per megawatt hour
CO_2e/a	carbon dioxide equivalent per annum
g/ml	grams per milliliter
GBq/a	gigabecquerel per annum
GJ	gigajoules
GJ/h	gigajoules per hour
GJ/a	gigajoules per annum
Ha/a	hectares per annum
kg	Kilograms
kg/min	kilograms per minute
kg/h	kilograms per hour
kg/week	kilograms per week
kg/bbl	kilograms per barrel
kg/m^3	kilograms per cubic meters
d_{50}	size in microns that splits the distribution with 50% above and below this diameter

kms	kilometers
km^2	square kilometers
KOH/g	potassium hydroxide per gram of oil sample
kPa	kilopascal
kV	Kilovolt
kMh	kilowatt hour
MWh	megawatt hour
mm	millimeter
m	meter
m^2	square meters
m^3	cubic meters
m^3/a	cubic meters per annum
m^3/tonne	cubic meters per tonne
m^3/s-h	cubic meters per stream hours
Mm^3	million cubic meters
µm	micrometer
t	tonnes
tph	tonnes per hour
tpsh	tonnes per stream hour
tpa	tonnes per annum
Mt	million tonnes
mPa.s	millipascal second
ppm	part per million
ppmw	part per million by weight
TiO_2	titanium dioxide
USD or US$	United States dollar
US$/bbl	United States dollars per barrel
US$/t	United States dollar per tonne
wt%	percentage by weight

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Summary

THIS PROCESS AND TECHNOLOGY OVERVIEW IS INTENDED TO PROVIDE AN OVERVIEW OF CVW CLEANTECH INC.'S (“**CVW CleanTech**” or the “**Company**”) PRE-COMMERCIAL PROCESS AND TECHNOLOGY AND IS NOT INDICATIVE OF ANY INTEREST THAT CVW CLEANTECH HAS OR MAY HAVE IN ANY PROJECT. CVW CLEANTECH DOES NOT HAVE ANY INTEREST IN ANY MINERAL PROJECT NOR IS IT ENGAGED IN ANY OIL AND GAS ACTIVITIES (EACH WITHIN THE MEANING OF APPLICABLE SECURITIES LAWS). THIS PROCESS AND TECHNOLOGY OVERVIEW IS PROVIDED FOR INFORMATIONAL PURPOSES ONLY AS OF THE DATE HEREOF AND MAY NOT CONTAIN CERTAIN MATERIAL INFORMATION ABOUT, INCLUDING IMPORTANT DISCLOSURES AND RISK FACTORS ASSOCIATED WITH, AN INVESTMENT IN CVW CLEANTECH. TESTING AND RESULTS THEREFROM MAY NOT BE INDICATIVE OF RESULTS RECEIVED FROM OPERATIONAL PROJECT DUE TO SCALING ISSUES AND OTHER UNKNOWN VARIABLES. ADDITIONAL INFORMATION RELATING TO CVW CLEANTECH CAN BE FOUND ON SEDAR AT WWW.SEDAR.COM.

1. Summary

CVW CleanTech's clean technology Creating Value from Waste™ ("**CVW™**") processes froth treatment tailings ("**FTT**") from mining oil sands operations to recover valuable hydrocarbons and 'green' critical minerals while delivering significant environmental benefits including greenhouse gases ("**GHG**") emissions reductions and enhanced tailings management. The processes have been validated through significant piloting and engineering and are ready for commercial implementation. A CVW™ project installation at a generic oil sands mining site is contemplated in this report, describing the socio-economic benefits of a commercial deployment, estimating:

- **2.2 million barrels** of hydrocarbons (1.9 MMbbl/a bitumen and 0.3 MMbbl/a solvent) recovered annually
- Production of **243,000 tonnes per year** of critical mineral (zircon, titanium) concentrates
- Between **380 – 850 thousand tonnes of CO_2e** abatement annually
- Up to **5,000 tonnes** of volatile organic compounds ("**VOC**") abatement annually
- Annual recovery and re-use of over **2.8 million m^3** water and **1.9 million GJ** heat integration
- Land-use reductions of over **19 Ha/a** consistent with the Alberta Energy Regulator's ("**AER**") Directive 85
- Annual revenue ranging from **$248 million** for a hydrocarbon-focused project to **$446 million** for a full facility that also produces critical mineral products

CVW CleanTech has invested over $100 million and over 15 years to research and develop CVW™ to Technology Readiness Level ("**TRL**") 8. Technology development is supported by large scale integrated piloting and progressive commercial engineering studies resulting in 20 active patents. CVW™ is comprised of physical separation operations, including flotation, solvent extraction and distillation with expected recoveries of 85% for bitumen and 91% for solvent currently lost to FTT. These hydrocarbon recoveries clean heavy mineral slurries for downstream processing to valuable critical mineral concentrates. Mineral processing operations utilize conventional mineral dressing equipment with expected recoveries of 73% of contained zircon and titanium minerals. The recovered hydrocarbons can be returned to the oil sands operator, thereby increasing their production efficiency, offering GHG (and cost) offsets through reduced extraction effort required to produce equivalent volumes of hydrocarbons. By recovering hydrocarbons from FTT, the CVW™ thickener is highly efficient with lower operating costs and environmental footprint (compared to conventional tailings management operations) to potentially deliver ready-to-reclaim solids depositions, thereby avoiding the use of tailings ponds and reducing annual land use footprint by ~3%. This process also recycles approximately 96% of the contained water providing 1.9 million GJ per year of indirect heat extraction and integration with process operations offsetting natural gas costs and related combustion emissions.

The CVW™ technology is designed to deliver significant GHG emissions avoidance and reductions at an oil sands mining site. Solvent lost to tailings ponds via FTT serves as a substrate for methanogenic fermentation in tailings ponds. The key to abating these fugitive methane emissions from tailings is to prevent this solvent from entering tailings ponds. CVW™ technology efficiently recovers solvent from FTT, reducing losses to tailings ponds and resulting in fugitive methane emissions avoidance of ~90% compared to current tailings pond emissions. A CVW™ project's GHG emissions profile includes tailings pond methanogenic emissions avoidance as well as upstream avoidances from equivalent hydrocarbon production and mining, critical minerals recovery, heat integration and project process emissions. The estimate range is based on varying methodologies used to estimate fugitive emissions and reported oil sands process emissions. The net incremental benefit of CVW™ implementation will reduce site-wide oil sands emissions by 5-12% annually.

Following successive front end engineering design ("**FEED**") studies in 2019 and 2021, CVW CleanTech in collaboration with an oil sands partner has developed Association for the Advancement of Cost Engineering ("**AACE**") Class 3 capital cost estimates that are utilized to develop generic project deployment options. These include a hydrocarbon only option (EcoBase) that contemplates recovery of bitumen and solvent while realizing the tailings management benefits and an enhanced GHG abatement profile. An EcoFlex option contemplates phasing in minerals production following the implementation of EcoBase. The EcoMax option represents the full project implementing hydrocarbon and minerals functions at the same time. Each of EcoBase, EcoFlex and EcoMax as defined herein in section 5.1. The economic metrics for each of the options are summarized below:

GENERIC CVW™ INSTALLATION AT 250,000 BBL/D SCO OIL SANDS MINING OPERATION		BASIS (C$)	ECOBASE (C$M)	ECOFLEX (C$M) PHASE 1	PHASE 2	ECOMAX (C$M)
REALIZED COMMODITY REVENUE**	SCO	$68.90/bbl	$110	$110		$110
	Naphtha	$78.00/bbl	$26	$26		$26
	Zircon concentrate	$1,339.58/t	—	—	$97	$97
	Chloride ilmenite	$635.76/t	—	—	$108	$108
	Subtotal		**$136**	**$136**	**$341**	**$341**
SAVINGS***	GHG abatement (2030)		$73	$73	$65	$65
	Tailings management		$33	$33		$33
	Heat integration		$7	$7		$7
	Subtotal		**$113**	**$113**	**$105**	**$105**
COSTS****	Operating expenses		$17	$17	$48	$48
	Transportation		—	—	$28	$28
	Bitumen royalties (Pre-Payout)		$3	$3		$3
	Bitumen royalties (Post-Payout)		$18	$18		$18
	Mineral royalties (Pre-Payout)		—	—	$2	$2
	Mineral royalties (Post-Payout)		—	—	$18	$18
	Subtotal (Post-Payout)		**$36**	**$36**	**$112**	**$112**
Initial Capital Cost*			**$390**	**$390**	**$726**	**$1,116**
Annual Sustaining Capital			**$8**	**$8**	**$23**	**$23**

* Capital cost estimates are based on a factorized approach from the Class 3 capital cost estimate prepared for the CVW™ Horizon project and are fully loaded with typical overheads (construction indirects, owner's costs and commissioning) and a contingency set by a third-party reviewer. These capital costs have been inflated by Canadian CPI from the date of the completed cost estimate. The engineering, procurement and construction period for the CVW™ installation is planned at 48 months. Initial capital costs for EcoFlex Phase 2 are incremental to Phase 1 capital costs.

** The recovered bitumen is upgraded to SCO at 85.4% yield and valued at West Texas Intermediate ("**WTI**") pricing net of any premium/discount and an upgrading processing fee of US$9/bbl. The recovered naphtha is valued at WTI pricing of US$60/bbl as benchmarked in this report. The zircon concentrate value is determined by the contained zircon content (~75%) less a 25% post processing discount against a US$1710/t premium grade zircon price. Chloride ilmenite is a blend of rutile, leucoxene and ilmenite and is valued by composition against rutile value of US$1320/t and US$314/t for ilmenite. Leucoxene is valued at 50% of the rutile value. The foreign exchange rate is set at C$1.30/$USD.

*** GHG benefits are valued at the federal carbon levy amounts that increase to $170/t by 2030. The GHG benefit, at 427,822 tpa CO_2e (based on industry reported fugitive emission data) for the EcoBase option is greater than the phased development full project installations, at 379,997 tpa CO_2e (based on industry reported fugitives data), due to reduced CVW™ process emissions. Tailings management savings are estimated at $21.47/tonne based on the volume of fine material processed and heat integration is valued at C$3.59/GJ.

****Operating costs have been developed from a bottoms-up approach to include labour, utilities, consumables, sustaining capital, laboratory costs and transportation. Bitumen royalties have been estimated using the Alberta Bitumen Royalty regime under a post-payout scenario at US$60/bbl WTI and Alberta's Bitumen Valuation Methodology (31.2%). Minerals royalties are based on Alberta's Metallic Minerals royalty rate (12% of net revenue) under a post payout scenario.

Financial markets and the public have been prioritizing Environmental, Social and Governance ("**ESG**") practices as an important measure of sectors for investment and market access to their products. The environmental impacts of oil sands mining tailings and associated tailings ponds have created reputational and competitiveness issues for the sector. A CVW™ project will enhance Canada's ESG reputation and associated competitiveness by addressing environmental aspects of oil sands mining tailings. A solution that re-processes a waste stream, prevents discharge to tailings ponds and reduces emissions into the atmosphere while recovering valuable lost products from the waste stream is a clean technology with positive implications for the industry. CVW™ technology is an innovative and sustainable end-of-pipe solution to realize both economic and environmental benefits from oil sands mining operations, while creating a new Canadian critical minerals industry in support of the emerging green and circular economies and contributing to Canada's net zero emissions aspirations. CVW™ complies with new tailings management regulations (AER's Directive 85), replacing the current practice of tailings pond deposition with resulting GHG emissions, and enhancing reclamation practices.

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Oil Sands Mining

2. Oil Sands Mining

2.1. Industry description and location

The oil sands mining sector has grown from its founding in 1967 at the Great Canadian Oil Sands project (now Suncor Energy Inc., "**Suncor**"), as a relatively small industry in the 1970's, growing rapidly throughout the next 30 years. By the 21st century, the oil sands of Northern Alberta included over 32 companies collaborating on 29 producing oil sands operations. Canada's oil sands currently include 161 billion barrels of reserves, representing the fourth largest oil reserves in the world (Canadian Association of Petroleum Producers, 2023). This resource base is expected to support stable production with opportunities for growth for the next 4-6 decades and is critical for the ongoing energy security of North America.

The oil sands resource, a heavy crude oil known as bitumen which is co-mingled with sand and water, is located in three regions in northern Alberta – Athabasca, Peace River and Cold Lake. The region is centered in the municipality of Fort McMurray at the confluence of the Athabasca and Clearwater Rivers, with all surface mines located within a 100 kilometer distance north of the city. The region is highly developed, with a population of over 72,000 (Statistics Canada, 2021), a regional airport, highway access, and an industrial service industry to support commercial oil sands operations. Manufacturing facilities and engineering services are located in Alberta (Edmonton and Calgary) and throughout Canada. Recent capital projects have utilized global supply chains to deliver significant project equipment through transportation networks.

Oil sands ore has a nominal bitumen grade of ~10% (Masliyah, Czarnecki, & Xu, 2011) and is accessible by surface mining and through "in situ" drilling methods to access reserves that are too deep to be mined economically. About 20% of the bitumen reserve is accessible by surface mining (Canadian Association of Petroleum Producers, 2022) in the Athabasca region, where some of the oil sands bitumen ore is less than 70 meters deep. Oil sands surface mining is a practice that involves conventional open pit excavation using trucks and shovels, crushing to enable transport to processing plants, and extraction using water-based separation processes (Canadian Association of Petroleum Producers, 2022). The recovered bitumen froth is cleaned using a solvent in a process known as froth treatment. There are currently six commercial oil sands mines operated by Suncor, Canadian Natural Resources Limited ("**Canadian Natural**") and Imperial Oil Limited ("**Imperial Oil**") producing over 1.6 MMbbl/d. The bitumen produced by froth treatment can then be upgraded to synthetic crude oil ("**SCO**") or other refined products.

The carbon emissions of oil sands mining are 4-6% above the global average crudes with an average intensity of about 85 kg CO_2e/bbl of SCO for mining facilities that have integrated upgrading facilities (Alberta Environment and Parks, 2021). The oil sands carbon footprint has been reduced by active measures taken by operators, with a 22% decline in emissions intensity between 2011 and 2018 (Canada Energy Centre, 2020).

2.2. Geological Settings and Mineralogy

2.2.1. Geology

Athabasca, Peace River and Cold Lake are the three Alberta oil sands regions (**Figure 1**). The Wabiskaw member and McMurray Formation are the main hosts of bitumen concentrations in the Athabasca oil sands deposit, which is the largest Alberta oil sands region at just over 93,000 km^2 (Alberta Energy Regulator, 2022).

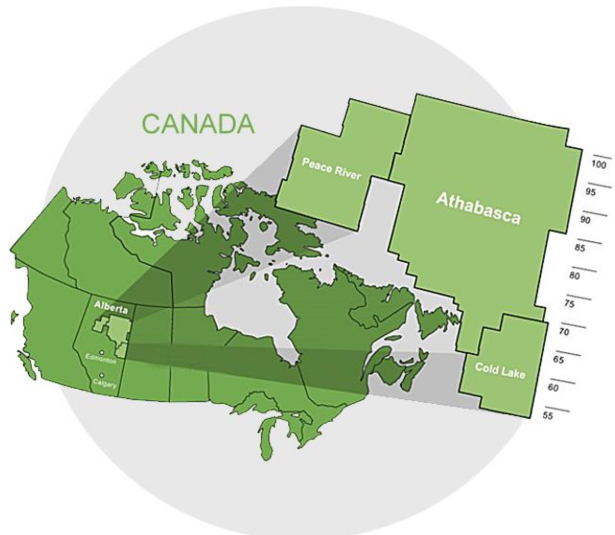

Figure 1. Oil Sands Deposits in Alberta (Alberta Energy Regulator, 2023).

As shorelines of the sea that covered much of ancient Alberta moved and inundated previously higher-ground regions 120 to 90 million years ago, the Cretaceous Interior Seaway expanded from the north to the south into a vast coastal complex of north-northwest incised valleys and bays. Deposition took place during an overall rise in sea level, leading to the development of the Cretaceous McMurray Formation. The topography present at the time of deposition during the pre-Cretaceous period influenced the McMurray Formation's initial placement. During the pre-McMurray period, the landscape was impacted by millions of years of deposition and erosion. As a result, deep valleys were cut into the underlying Devonian carbonates by erosion, which eventually contained McMurray depositional systems. The river channel deposits that are frequently retained in the deepest sections of the Devonian valley systems make up the majority of the extraordinarily complex depositional settings that make up the McMurray region. The lower McMurray fluvial channels within the erosional valley complexes are where the coarse-grained pebbly, gravelly sand was deposited. These sands are typically permeable. In the middle of the McMurray Formation, deposition changed upward into more transgressive estuarine settings. The fluvial-tidal estuarine point bar deposits with fluctuations in sand grain sizes that go from fine to medium, and lithology such as mudstones breccias, low-angle inclined heterolytic stratification deposits of mud and sand, dominated the tidally-influenced estuaries (Alberta Energy Regulator, 2022).

Since oil sands shallower than 75 meters are excavated using open pit mining techniques, only 20% of the Athabasca oil sands deposit is considered to be mineable. Overburden clearing becomes prohibitively expensive for areas deeper than this, necessitating subterranean in-situ techniques utilising steam or steam mixed with solvents, often known as steam assisted gravity drainage (Canadian Association of Petroleum Producers, 2022).

Fine-grained sand (38 to 250 microns), clay, water, and bitumen are all components of oil sands. Bitumen is a very thick oil that does not flow on its own; it can be up to four times more viscous than peanut butter. The viscosity of the bitumen is decreased by adding heat or other lighter hydrocarbons, allowing it to flow (Alberta Energy Regulator, 2022).

2.2.2. Bitumen

Athabasca bitumen is emanated from oil-rich shales which had been deposited in a marine environment preserving organic matter such as algae, plankton and other organisms. These organics are formed into a high molecular weight kerogen and its deposits represent the source of petroleum around the globe. Over time, with pressure and heat, the polymer-like kerogen cracks to release molecules that form crude oil. During the Cretaceous period, crude oil from deep source shales in southwestern Alberta migrated to northern Alberta to deposit in the river and estuary sands of the McMurray Formation. The deposited crude was then subjected to biodegradation owing to its shallow deposition, impacting its density, sulphur content and metals concentrations (Hein, Marsh, & Hurst, 2013). Commercial oil sands ore is characterized by bitumen content greater than about 6% and the fine particle content is also considered in regard to processability, with average fines content in the 20% range (Masliyah, Czarnecki, & Xu, 2011).

Bitumen is characterized by its physical properties, elemental composition and solubility classifications (**Table 1**). The United Nations Institute for Training and Research defines bitumen as an extra heavy oil with an American Petroleum Institute ("**API**") gravity of less than 10° at 15.6°C and viscosity greater than 10^5 mPa.s at deposit temperature (Shaw, Schramm, & Czarnecki, 1996). The carbon and hydrogen content of bitumen is typified over a narrow range of atomic hydrogen-to-carbon ratio averaging at about 1.5 and heteroatom content of 4-5% and less than 1% by weight for sulphur and nitrogen, respectively. Metals, primarily vanadium and nickel, are found in concentrations up to a few hundred parts per million.

The hydrocarbon components of bitumen can also be classed into fractions based on solubility in solvents of decreasing polarity and/or adsorption characteristics. Crude oils are dominated by a maltenes fraction that is soluble in highly polar solvent such as pentane. The insoluble precipitate is known as asphaltenes. The maltenes can be further separated by column chromatography into resins (maltenes adsorbed by silica gel), aromatics (unsaturated, ringed hydrocarbons) and saturates (saturated hydrocarbons). Bitumen is typified by about 17% asphaltenes, 25% resins, 40% aromatics and 17% saturates (Rahimi & Gentzis, 2006).

Table 1. Physical properties, chemical composition and solubility classification of Athabasca bitumen.

PROPERTY	VALUE	SOURCE
API gravity	<10º	(Shaw, Schramm, & Czarnecki, 1996)
viscosity	>105 mPa.s	(Shaw, Schramm, & Czarnecki, 1996)
H/C	1.5	(Bichard, 1987), (Rahimi & Gentzis, 2006)
Sulphur	4-5%	(Gray, 1994)
Nitrogen	≤0.5%	(Bichard, 1987), (Gray, 1994)
Metals	280 ppmw	(Gray, 1994)
Saturates	17%	(Rahimi & Gentzis, 2006)
Aromatics	40%	(Rahimi & Gentzis, 2006)
Resins	25%	(Rahimi & Gentzis, 2006)
Asphaltenes	15-20%	(Bichard, 1987), (Speight, 1991), (Rahimi & Gentzis, 2006)

2.2.3. Mineralogy

It has been known for many years and well documented in literature that critical heavy minerals can also be found in Alberta's oil sands. A 1996 study by the Mineral Development Agreement (Simons, 1996), shows that although the heavy minerals vary greatly in their concentrations, they occur in virtually every geologic horizon within the Athabasca oil sand deposit. Typical heavy mineral content values of the run-of-mine ore values are in the range of 0.25% to 0.50% heavy minerals (Oxenford, Coward, Bulatovic, & Liu, 2003).

No low ore concentrations have been identified, and the heavy mineral concentrations remain generally constant throughout most of the Athabasca McMurray Formation. The heavy minerals are typically fine grained, with a d50 of less than 100 µm. In contrast to many deposits of heavy mineral sands, there hasn't been any post-depositional reworking of the sediments. Secondary mineralization is frequent in the reducing post-depositional environment. The recovery rates in mineral processing are impacted by some secondary minerals' frequent intergrowths or inclusions in other minerals (Simons, 1996).

Heavy minerals are described as minerals with a density of more than 2.65 g/ml and in the mineral sands industry measured as the mass percent of sinks when subjected to a heavy liquid (such as tetrabromo-ethane) separation at a density of 2.90 g/ml (ALS, 2023). For oil sands, the total heavy mineral ("**THM**") fraction obtained from the heavy liquid separation step, typically contains the following heavy minerals: ilmenite, altered ilmenite, leucoxene, rutile, zircon, pyrite, tourmaline, garnets and minor to trace amounts of siderite, monazite, xenotime, chromite and other silicates (Simons, 1996). The minerals with economic value are referred to as valuable heavy minerals ("**VHM**") and consists of TiO2-containing minerals (ilmenite, altered ilmenite, leucoxene, and rutile) and zircon. In oil sands, the heavy minerals are preferentially oil wet, so the process of recovering the bitumen from the mineable oil sands also recovers the heavy minerals. When these solids are removed in the bitumen froth clean-up step (within a froth treatment plant), the tailings from that process are greatly enriched in TiO2 and zircon, resulting in a concentrated THM content of 15-30%, compared to typical mineral sand deposits with 2-5% in-situ THM content (Chachula & Erasmus, 2007).

2.3. Current Production Profiles

World energy demand including oil demand is forecast to increase 30% by 2040. The oil sands are a vital resource for Canada and the world, representing the world's 4th largest oil reserves and over 50% of the world's accessible reserves. It is estimated the oils sands sector will contribute one trillion dollars to the Canadian economy over the next 10 years and almost 166,000 Canadian jobs rely on the oil sands (Canadian Association of Petroleum Producers, 2022).

Oil sands surface mining is currently comprised of six operating assets in the Athabasca oil sands region. These include Suncor's base mine ("**Base Mine**") and Fort Hills mine, Syncrude Canada Ltd.'s ("**Syncrude**") Mildred Lake and Aurora mines operated by Suncor, Canadian Natural Upgrading Limited's ("**CNUL**") Muskeg River ("**MRM**") and Jack Pine ("**JPM**") mines, Canadian Natural's Horizon mine and Imperial Oil's Kearl mine. Their recent daily bitumen production performance is presented in **Table 2**. Production from surface mining has been approximately 1.6 million bbl/d in recent years, with growth of over 30%.

Table 2. Daily bitumen product production in bbl/d by operators of Canada's oil sands surface mining sector over the period of 2016-2022. Values obtained from the AER (Alberta Energy Regulator, 2023) and reported as calendar day production. Sector totals are reported in kbbl/d.

OPERATOR	PROJECT	START-UP	2016	2017	2018	2019	2020	2021	2022
Suncor	Base Mine	1967	239,003	304,739	258,676	289,763	263,044	276,033	257,868
Syncrude	Mildred Lake/ Aurora	1978	330,807	306,509	304,790	361,324	336,615	352,136	375,203
CNUL	MRM/JPM	2002	257,422	274,226	295,840	290,788	274,024	332,395	303,745
Canadian Natural	Horizon	2009	146,705	196,762	263,868	233,392	270,657	260,196	257,920
Imperial Oil	Kearl	2013	185,838	196,157	222,655	220,646	240,144	281,306	260,047
Suncor	Fort Hills	2018	—	2,104	129,841	163,823	112,337	97,252	163,634
	Total (kbbl/d)		1,160	1,280	1,476	1,560	1,497	1,599	1,618

The Canadian Association of Petroleum Producers ("**CAPP**") has estimated that mined bitumen production will reach about 1.9 MMbbl/d by 2035 (Canadian Association of Petroleum Producers, 2022), representing an approximately 20% increase relative to 2022 production (**Figure 2.**). These forecasts include the Frontier Oil Sands Mine Project, by Teck Resources Limited (the "**Teck Project**", Phase 1 production of ~170,000 bbl/d), which was withdrawn in 2020. Accounting for this, it appears that there will be ~6% growth and mining bitumen production may be expected to reach about 1.7 million bbl/d going forward through 2035 with incremental production increases achieved through debottlenecking, reliability and capacity addition activities.

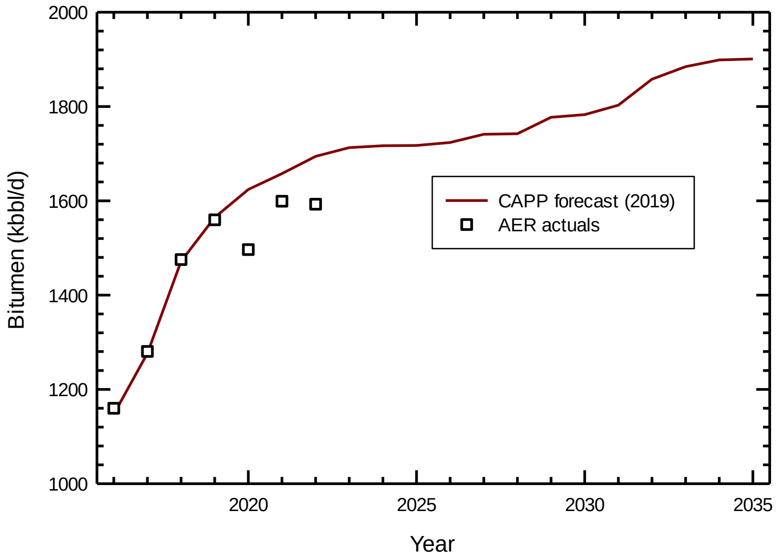

Figure 2. Mined oil sands bitumen production forecast through to 2035, in kbbl/d (Canadian Association of Petroleum Producers, 2019). Also shown is the mined bitumen production to 2022 as reported to the provincial regulator. Note that CAPP forecast data for 2022 onwards includes the Teck Project with 170,000 bbl/d of production.

2.4. Carbon Emissions and the Environment

A decade ago, oil sands mining SCO production emissions intensity was in the range of 100 kg CO_2e/bbl (IHS Energy, 2014) and ranked amongst the highest heavy oil emitters (**Figure 3**). The majority of emissions result from the combustion of hydrocarbons (i.e., natural gas) and electricity consumption, which represents about 10-25% of total process emissions (Alberta Environment and Parks, 2021), (Alberta Energy Regulator, 2023). Up to ~10% of site-wide emissions are due to fugitive biogenic tailings ponds releases (Alberta, 2017). Since then, net oil sands mining emissions have been reduced by 14% while production has increased by 59% (Canadian Association of Petroleum Producers, 2021), with intensities ranging down to about 75 kg CO_2e/bbl, with an average of 90 kg CO_2e/bbl (IHS Markit, 2022). Even with improved performance, the oil sands industry continues to be under increased environmental scrutiny as concerns about carbon emissions in the exploration and production process, along with the management and remediation of resulting waste streams, have become increasingly urgent areas for the industry. Critical factors for both the sustainability and profitability of the industry are reducing the industry's environmental footprint, particularly GHG emissions and tailings ponds, and reducing operating costs, all areas where CVW CleanTech's technology is expected to deliver meaningful improvements and benefits.

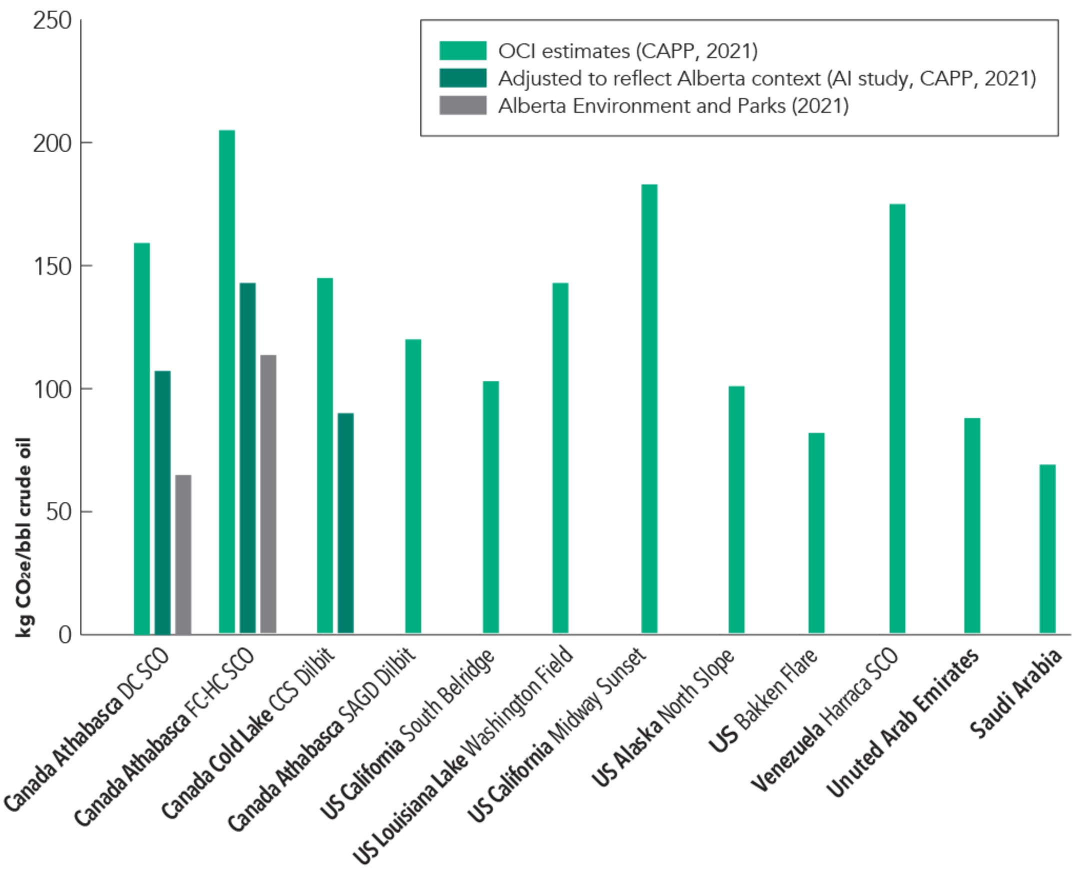

Figure 3. Emissions intensities for select sectors including Canadian minable oil sands (labelled "Athabasca DC SCO" and "Athabasca FC-HC SCO") with comparisions to US and Venezualan crudes. Adapted from (Canadian Association of Petroleum Producers, 2021) and (Jing, El-Houjeiri, Monfort, Brandt, & Masnadi, 2020).

03

CVW™ Process Overview

3. CVW™ Process Development

3.1. Overview

CVW™ is an innovative end-of-pipe technology designed to intercept oil sands FTT before discharge to ponds and fully remediate tailings while recovering valuable commodities including bitumen and solvents which are a source of methane emissions and other environmental impacts when deposited in ponds as well as minerals currently lost to tailings ponds. It is designed to integrate with a host oil sands mining site (**Figure 4**).

Oil sands ore, containing bitumen and low concentrations of minerals, is excavated in open pit mines via truck and shovel operations (Area 1, **Figure 4** The ore is then crushed and mixed with water and then pumped (Area 2, **Figure 4**) to the extraction plant. The hydrotransport process ablates ore lumps and liberates bitumen. In the extraction plant (Area 3, **Figure 4**) a warm water separation process is employed to separate the bitumen from the bulk of the slurry. The extraction operations include large gravity settlers to collect a primary bitumen froth and, at some facilities, flotation units to augment the recovery of bitumen to the froth product. The resulting intermediate product is a bitumen froth, which still contains significant amounts of solids and water. A majority of contained critical minerals are retained with the bitumen in the bitumen froth.

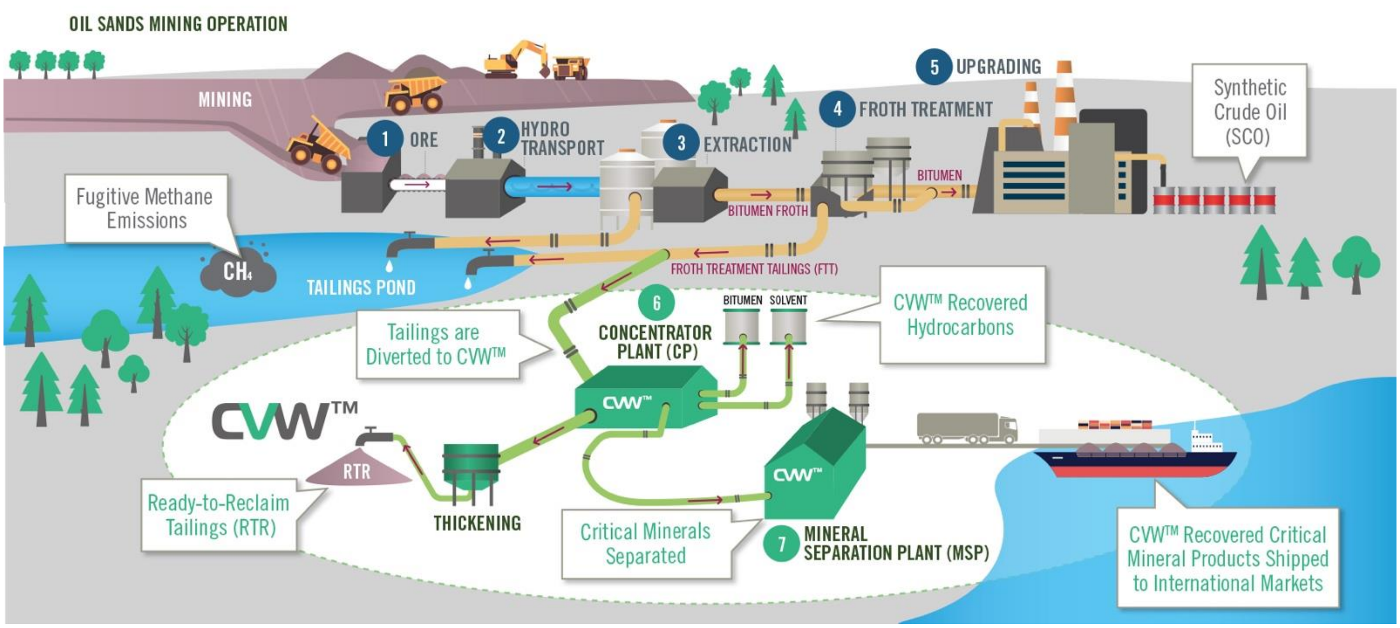

Figure 4. Generalized drawing of CVW™ technology integrated at an oil sands mining site. The tailings from the froth treatment operation contain about 2% bitumen, about 0.2% naphtha (or paraffinic solvent) and 15% solids (Tipman, 2013). The valuable minerals in this solids fraction are significantly enriched to a concentration of 15-25% (Cui, Liu, Etsell, Oxenford, & Coward, 2003). The FTT which represent about 5% of site-wide tailings (Thitakamol & Zhuang, 2021), are currently deposited in tailings ponds, where methanogens ferment the naphtha, releasing significant fugitive methane and carbon dioxide volumes.

Before being upgraded to SCO, the bitumen froth is cleaned in a process known as 'froth treatment' (Area 4, **Figure 4**). In mining operations with an onsite upgrader, a naphtha diluent is used in the froth treatment process to separate a clean diluted bitumen from the water and solids. In mining sites where upgrading is conducted off-site, a paraffinic solvent is used in froth treatment to produce a diluted bitumen that is partially de-asphalted. Diluted bitumen recovery of 96-99% (Thitakamol & Zhuang, 2021) is achieved using solvent extraction in gravity settlers, including inclined plate settlers arranged in counter-current decantation configurations and centrifuges. The solvent is recovered from FTT in flash columns, often incorporating steam stripping. The cleaned diluted bitumen then continues to the upgrader (Area 5, **Figure 4**), where it is processed into SCO and/or refined products.

CVW™ technology is designed to intercept the entirety of the FTT stream before it is deposited into the tailings ponds, thereby preventing the naphtha (or paraffin) from entering the pond and abating a significant portion of these fugitive methane emissions. The technology is comprised of two plants – a concentrator plant ("**Concentrator Plant**" or "**CP**", Area 6, **Figure 4**), a mineral separation plant ("**Mineral Separation Plant**" or "**MSP**", Area 7, **Figure 4**) and a thickener that processes tailings from the CP and MSP. The recovered diluted bitumen and naphtha are of high quality and can be integrated into the host site upgrader and/or solvent recovery unit to produce incremental volumes of SCO. The mineral concentrates that would be produced in the MSP – a zircon concentrate and a titanium feedstock product (chloride ilmenite with 72% TiO_2) could be exported to global markets.

3.2. Process Description

CVW™ performs a series of physical separation processes which utilize large scale, proven technologies currently in use in oil sands mining operations uniquely modified and configured for FTT. The Company's sustainable tailings remediation technologies are comprised of several processing stages. A simplified flow sheet of the CVW™ technology tailings remediation is shown in **Figure 5** with integration at an oil sands mining host site.

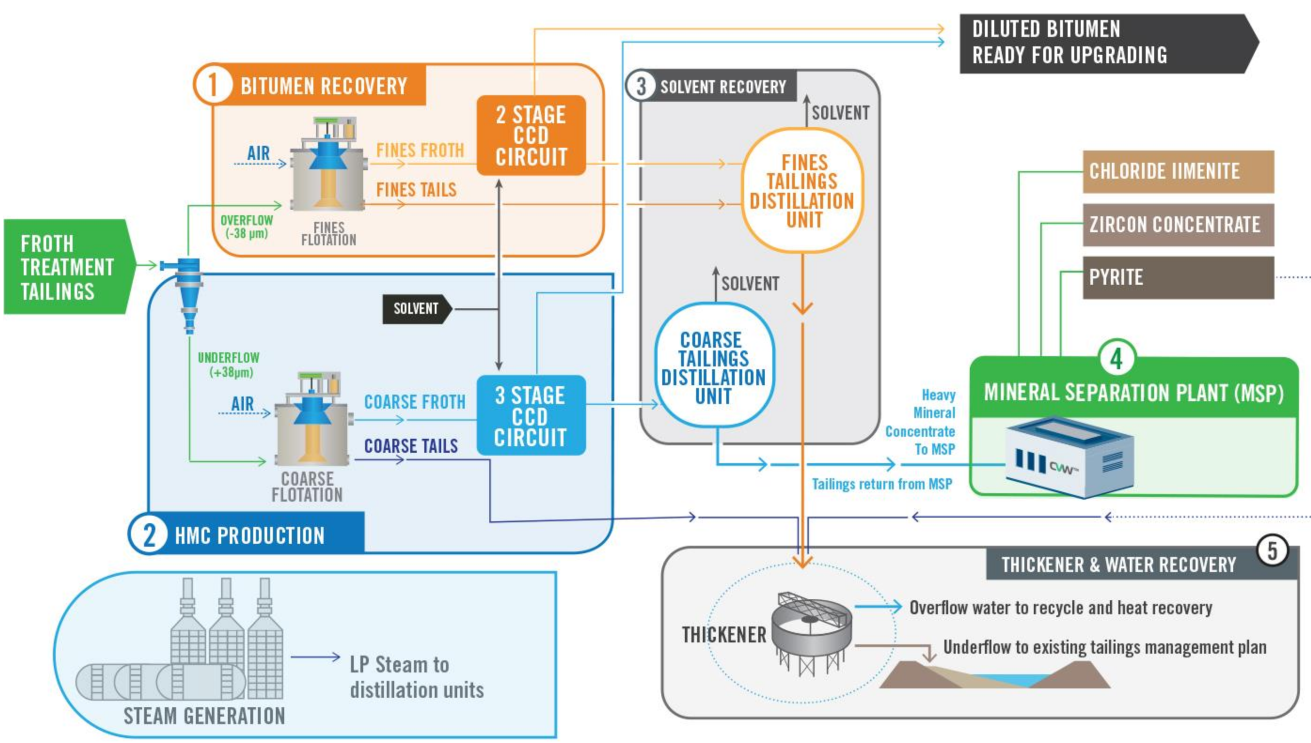

Figure 5. Generalized schematic drawing of the CVW™ technology integrated with an oil sands mine host site. The Concentrator Plant is comprised of the bitumen recovery and heavy mineral concentrate ("**HMC**") production areas, both of which have solvent recovery tailings distillation units ("**TDU**") circuits incorporated. Process solvent is supplied and recovered excess is returned to the host site.

- **Bitumen Recovery (“Fines” Circuit; Figure 5, Area 1):** FTT are fed into a cyclone to classify solids into coarse minerals (+50μ) and fines (-50μ) fractions. The plurality of bitumen resides with the fines fraction and the focus of this circuit is to recover contained bitumen. The bitumen is recovered from the fines fraction by flotation and extraction utilizing the host site solvent (i.e., naphtha or paraffin) in a counter-current decantation circuit. The cleaned tailings streams are processed to recover any lost solvent using distillation. The recovered diluted bitumen meets upgrader feed specifications and can be processed by the host site to SCO (or added to the partially de-asphalted bitumen sales stream).
- **HMC Production (“Coarse” Circuit; Figure 5, Area 2):** The coarse mineral fraction of FTT, obtained by classification as described above, is contaminated with bitumen and also contains a significant fraction of gangue. The purpose of this Coarse circuit is to remove unwanted solids and enrich the valuable minerals into a HMC, and then remove the bitumen that coats the HMC particle surfaces. The bitumen must be removed from the HMC to avoid fouling and sub-optimal performance in the downstream MSP. The HMC is produced from the coarse fraction via selective flotation, which rejects silica-based gangue. Bitumen is then recovered from the HMC using multistage counter-current solvent washing, again using a host-derived solvent as the extractant. The produced HMC is then processed in the Mineral Separation Plant. The bitumen removed from the HMC is of high quality and can be upgraded at the host site facilities into SCO (or added to the partially de-asphalted bitumen sales stream). The HMC is then processed to recover any lost solvent using distillation.
- **Solvent Recovery (Figure 5, Area 3).** The preceding functions produce a fines tailings and HMC slurry that contains the process solvent. This solvent must be removed and recovered to maximize environmental and economic benefits. CVW™ achieves this with dedicated TDU for each of the fines tailings and HMC slurry. These TDU circuits utilize steam to distill naphtha from the feed slurries. The recovered naphtha can be recycled within CVW™ to reduce pool naphtha draw from the host site. Compared to related commercial technologies in the oil sands, the CVW™ TDU performance is enhanced due to the removal of bitumen from the FTT, altering the tailings liquid-vapour equilibrium and superior performance is observed. The distilled tailings/HMC are characterized by very low naphtha concentrations, realizing significant methane emissions reductions in downstream tailings ponds. Consequently, when combined with other off-gas capture technology, the residual naphtha and methane released from oil sands FTT will be reduced by approximately 90% relative to the current level of emissions.
- **Minerals Separation (Figure 5, Area 4):** With hydrocarbons removed, the heavy minerals concentrate is processed to separate valuable minerals into concentrates using conventional mineral sands processing operations. These operations utilize proven technology including gravity spirals and shaker tables, wet magnets, high tension rolls and magnetic separators that are used by the global mineral sands industry. While using conventional technologies, the mineral dressing operations have been designed to recover finer grades of valuable minerals utilizing gravity spirals, flotation and dry mill reprocessing (Canada Patent No. 2887722, 2017). The current embodiment of the MSP processes HMC into two products: a zircon concentrate and a chloride ilmenite, which contains titanium bearing minerals including rutile, leucoxene and ilmenite.
- **Tailings Management and Water Recovery (Figure 5, Area 5):** The tailings from the flotation circuits of the bitumen recovery and HMC production circuits, the raffinate from the TDU of the bitumen recovery circuit and MSP tailings are sent to a thickener. The purpose of the thickener is to dewater the CVW™ tailings and prepare them for integration with the host site tailings management plan. This thickening operation is highly efficient due to the low residual hydrocarbon values leading to efficient dewatering (Mikula, 2010). The recovered hot water allows for heat integration with the oil sands operator, further eliminating GHG emissions associated with reheating process water, and is of sufficient quality for re-use applications within the CVW™ process and at the host site. The CVW™ thickener leads to reduced water-use intensity and land-use intensity at the integrated host site. The recovered water is suitable for re-use applications in the mining and extraction functions. The incremental recovery of hydrocarbons and release of re-use water, reduces the growth of the mine and tailings footprints.

3.3. Technology Competitiveness

A key to CVW™ technology's environmental performance is its efficacy for recovery of hydrocarbons – both bitumen and solvent – from tailings as well as the effective separation of critical minerals into saleable products. The Alberta government, the Federal government, and the oil sands industry encouraged and supported the development of CVW™ to increase resource recovery, sustainability and abate the environmental impacts of FTT. After over $100 million of development, CVW™ technology remains the only commercially-ready tailings remediation process that delivers significant GHG emissions reductions.

The Company is not aware of any viable alternatives to achieve those objectives, either historical or under development, that have undergone extensive research and development ("**R&D**") and piloting phases and reached a mid-level TRL versus CVW™ technology that is at an advanced stage of TRL 8. Several organizations have attempted to develop technology 'partial' solutions for FTT (**Table 3**). However, these technologies largely focus on bitumen removal, minerals recovery and/or heat recovery from tailings and do not deliver a comprehensive solution for FTT remediation and recovery of valuable hydrocarbons and minerals.

Table 3. Listing of select froth treatment processing competitor technologies public disclosures, including Canadian Patent references, provided.

COMPANY	TECHNOLOGY	DESCRIPTION (FTT PROCESSING)
Imperial Oil	Minerals (CA 2674660)	Bitumen removal via combustion; oxides HMC limiting separability (2011)
Imperial Oil	Thickener; COSIA T-267 (Alberta Innovates, 2012)	Tailings management, heat recovery, no provision for naphtha recovery; thickened slurry ~40% solids (2012)
Gradek	Oleophilic beads (CA 2679822)	Bitumen, minerals; no provision for naphtha recovery; pilot scale (TRL ~6)**, low bitumen recovery (70%); no longer active (2014)
Suncor	Flotation (CA 3077715)	Mineral recovery via flotation using oxidizing agent; lab scale (TRL≤3)** (2015f)
Syncrude	Flotation (CA 2864857)	Bitumen recovery via flotation, low bitumen recovery kinetics; lab scale (TRL≤3)** (2016)
Syncrude	2 Stage NRU (CA 3064978)	Naphtha recovery; Complex 2 stage process (atm, vacuum, fines/coarse split); residual naphtha ~ 0.1-0.3 wt%; lab scale (TRL≤3)** (2019f)
Suncor	Flotation, air stripping (CA 3048272)	Bitumen recovery via flotation and concentration, naphtha removal via air stripping; lab scale (TRL≤3)**, (2019f)
Queen's Univ. (COSIA)	TEA manipulation* (COSIA, 2020)	TEA/nutrient addition to limit biogenic fermentation; no provision for naphtha recovery; lab scale (TRL≤3)**, (2020)
Suncor	Flotation, chemicals (CA 2983961)	Bitumen recovery via flotation and concentration, and/or underflow chemical treatment, and/or naphtha removal via air stripping; lab scale (TRL≤3)**, (2022)
Suncor	Biodegradation (CA 3059673)	Active biodegradation of light hydrocarbons – destructive with CO_2 release, does not address bitumen/minerals, (2022)

* TEA – Terminal Electron Acceptor; COSIA Project TE0055 RWG (IOSI18), 2020

** TRL – Technology Readiness Level; Clean Growth Hub Technology Readiness Level (TRL) Assessment Tool - Clean Growth Hub (ic.gc.ca)

As such, CVW CleanTech's tailings remediation solution has a "first mover" advantage while providing a comprehensive solution to the oil sands mining industry. The CVW™ technology has successfully advanced through years of progressive development, piloting, due diligence and engineering necessary for innovative technology solutions in the oil sands industry. The CVW™ technology is patent-protected, and the combined investment and time required to develop this type of large-scale clean technology solution should provide a sustained technology advantage over other alternatives.

3.4. Intellectual Property

There are numerous innovative aspects to the CVW™ suite of technologies with the below being the most relevant to enhancing hydrocarbon recovery performance and minerals recovery, mitigating naphtha losses and significantly reducing methane and other emissions. The Company's active patents are listed in **Table 4**.

- **Low Solvent Loading.** An important innovative feature of the solvent extraction circuits, enabled in part by careful conditioning during flotation, is the low solvent loading required to achieve high bitumen recovery values. The solvent loading is approximately 75%+ lower than other solvent extraction technologies used to recover bitumen from oil sands and process tailings. This important operational parameter contributes to making the CVW™ process commercially accessible and financially attractive.

- **Intra-phase Recycle and Differential Underflow**. Other CVW™ innovations incorporated into the solvent extraction circuit include an 'intra-phase recycle' stream and 'differential underflow' circuit operation. These innovations prevent rag layer formations and improve the quality of the recovered diluted bitumen.
- **Vapour Liquid Equilibrium.** The CVW™ solvent recovery units are based on an innovative operation designed to recover diluents that can be recycled into the process. These distillation units exploit the immiscibility between the aqueous tailings and naphtha (solvent) which lowers the boiling point of the tailings and allows for enhanced naphtha recovery. The Company's distillation units embody design enhancements to increase mass transfer and attain vapour liquid equilibrium.
- **Fine Mineral Recovery.** FTT solids include a portion of fine-grained valuable minerals that would be rejected to waste streams in conventional mineral processing. CVW CleanTech has developed a process to retain meaningful values of fine zircon sand via selective flotation and other amendments to typical mineral unit operations.

Table 4. Comprehensive list of CVW CleanTech's active patents.

	PATENT #	TITLE	JURISDICTION	ISSUED	EXPIRY
1	7341658	Recovery of heavy minerals from a tar sand	USA	2008-03-11	2024-09-02
2	2548006	Process for recovering heavy minerals from oil sand tailings	Canada	2014-04-22	2026-05-25
3	7695612	Process for recovering heavy minerals from oil sand tailings	USA	2010-04-13	2027-09-20
4	2662346	Recovery of bitumen from froth treatment tailings	Canada	2013-04-02	2029-04-09
5	8382976	Recovery of bitumen from froth treatment tailings	USA	2013-02-26	2031-12-12
6	2693879	A method for processing froth treatment tailings	Canada	2012-09-18	2030-02-22
7	8852429	Method for processing froth treatment tailings	USA	2014-10-07	2032-12-05
8	2712725	Apparatus and method for recovering a hydrocarbon diluent from tailings	Canada	2012-11-27	2032-08-30
9	2768852	Apparatus and method for recovering a hydrocarbon diluent from tailings	Canada	2014-08-26	2031-05-11
10	9314713	Apparatus and method for recovering a hydrocarbon diluent from tailings	USA	2016-04-19	2034-04-19
11	2743836	Methods for separating a feed material derived from a process for recovering bitumen from oil sands	Canada	2015-05-19	2031-06-21
12	9719022	Methods for separating a feed material derived from a process for recovering bitumen from oil sands	USA	2017-08-01	2033-04-01
13	2839509	Methods for separating a feed material derived from a process for recovering bitumen from oil sands	Canada	2016-04-12	2031-06-21
14	10087372	Methods for separating a feed material derived from a process for recovering bitumen from oil sands	USA	2018-10-02	2030-08-08
15	2887722	A method for producing a zirconium concentrated product from froth treatment tailings	Canada	2017-01-24	2033-10-10
16	2016/03003	A method for producing a zirconium concentrated product from froth treatment tailings	South Africa	2018-02-28	2033-10-10
17	2013402871	A method for producing a zirconium concentrated product from froth treatment tailings	Australia	2017-06-15	2033-10-10
18	9694367	A method for producing a zirconium concentrated product from froth treatment tailings	USA	2017-07-04	2033-10-10
19	2932835	Process for recovering bitumen from froth treatment tailings	Canada	2018-06-12	2036-06-13
20	10017699	Process for recovering bitumen from froth treatment tailings	USA	2018-07-10	2036-08-16

CVW CleanTech holds 20 active patents covering all aspects of the CVW™ technology including bitumen recovery, solvent recovery and valuable critical minerals production. Patents are held in four jurisdictions (Canada, the United States ("**USA**"), Australia, and South Africa). All intellectual property was developed and is owned by CVW CleanTech, with one patent being 50% co-owned. The co-owned patent describes one aspect of the overall CVW™ process and relies on additional intellectual property for desired performance. The co-ownership agreement allows the co-owner to deploy the technology at the co-owner's oil sands project, with CVW CleanTech retaining the right to propose and negotiate arrangements, and deploy the technology elsewhere. The Company's active patents are listed in **Table 4** and form a strategy to provide a competitive advantage in the future. No other IP is held by others that may impede freedom to operate in the oil sands industry. CVW CleanTech's patents reside in the intellectual space uniquely among peer technologies and remain licensable for oil sands applications through fair, reasonable and non-discriminatory terms.

3.5. R&D Overview

CVW CleanTech's FTT remediation technology is the result of over 15 years of progressive development, internally and at best-in-class research institutes and engineering firms worldwide. This included foundational R&D followed by years of piloting at a significant scale at CanmetENERGY's world class oil sands technology demonstration facility in Devon, Alberta for a consortium of oil sands operators and Alberta and Federal government agencies. Subsequently, the Company has completed multiple project FEED studies and a validation study that provide important environmental advancements as well as site-specific engineering information to provide critical project and technology de-risking for a first commercial installation at an oil sands mine (refer to **Project Description** below). Accordingly**,** CVW™ technology is at TRL 8. Canadian Oil Sands Innovation Alliance ("**COSIA**") has previously indicated that CVW CleanTech's technology is fully validated and ready for commercial deployment (COSIA, 2015). The Company's program is outlined in **Figure 6** which features select activities across the project development spectrum, which was executed under an open innovation model to leverage the best available technologies and accelerated development through knowledge transfer. Highlights of the progressive development pathway are indicated in **Figure 7**.

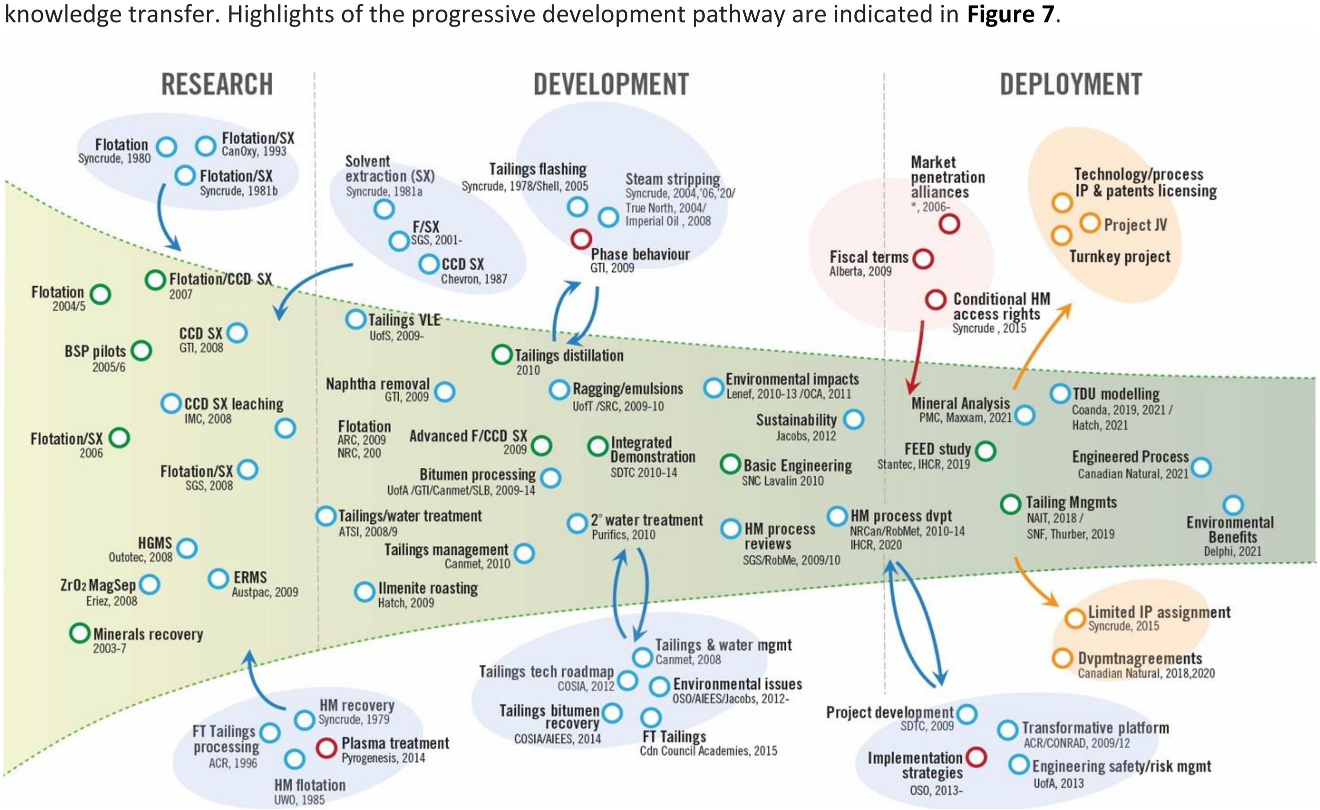

Figure 6. CVW CleanTech's open innovation technology development funnel highlighting select technology R&D and project development activities.

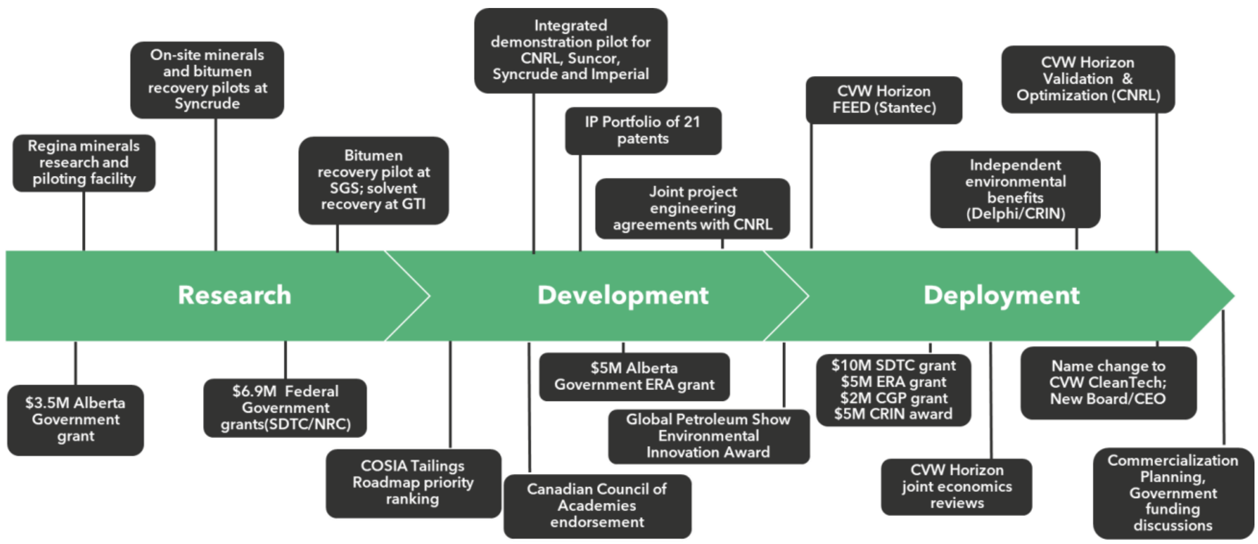

Figure 7. CVW CleanTech's key R&D, project, financing and recognition activities.

3.5.1. Mineral Testing

3.5.1.1. Regina Facility (2004-2009)

CVW CleanTech established and constructed a $7.0 million oil sands tailings and minerals pilot facility at the Saskatchewan Research Council campus in Regina in 2004 (**Figure 8**). The initial technology focus was heavy minerals recovery from beach sands from the tailings ponds. After consultation with the industry, the Company's program shifted to mineral extraction from FTT. In this testing, bitumen removal, required to avoid equipment fouling and improve mineral recoveries, was accomplished by thermal decomposition. However, this solution had an impact on potential mineral recoveries and alternative bitumen removal strategies were sought. The program culminated with including on-site pilots at Syncrude's Mildred Lake mine in 2005 and 2006 which featured a 'bulk flotation' circuit to produce a HMC. In the 2006 campaign, the first piloting of solvent extraction was conducted to recover bitumen in quality that would facilitate downstream upgrading, an important factor identified by the industry.

Figure 8. Regina facility wet mill (left) and 2006 Bulk Separation Plant ("**BSP**") pilot at Syncrude's Mildred Lake (right).

3.5.1.2. Recovery Optimization (2007-2015)

As the hydrocarbon removal programs were advanced, the Company refocused efforts on the production of value-added mineral products, including a premium grade zircon sand and titanium mineral product. Several research projects by established mineral testing firms (Austpac Resources N.L., Eriez Manufacturing Co., Metso Outotec Corporation, and Xstrata) were implemented to better understand and advance aspects of the mineral processing options. These included roasting ilmenite to improve its magnetism, magnetic processing to reduce the titanium content of zircon concentrates, the performance of new 'fine grade' mineral spirals, and advanced analytic techniques. IHC Robbins Pty Ltd ("**IHC Robbins**"), mineral process development experts based in Australia, were retained to execute various testing programs that resulted in significant improvements to product quality and recovery. These were achieved using conventional dressing equipment including Kelsey Jigs, which were new to the CVW CleanTech's mineral processing scheme.

3.5.1.3. Concentrates Processing (2020 – 2021)

CVW CleanTech engaged with IHC Robbins again in 2020 to 2021 during the Company's FEED and validation engineering, to optimize the project's mineral product suite to zircon concentrate and chloride ilmenite. The processing scheme resulted in meaningfully higher recovery of valuable minerals (zircon, rutile, leucoxene, and ilmenite) to concentrates compared to earlier processing circuits that reduce capital and operating costs while enhancing revenues and project economics.

3.5.1.4. Industry Sampling Campaign (2005 – 2022)

In conjunction with CVW CleanTech's various piloting campaigns, the Company also evaluated and tracked the heavy minerals in the FTT of oil sands operators, including Syncrude, Suncor and Canadian Natural, over a period of several years. Oil sands operators are required to sample their FTT daily to determine the bitumen and naphtha contents, using the Dean-Stark solvent distillation extraction process. The resulting cleaned and dried solids were retained for the Company's evaluation purposes.

From 2005 to 2014, daily samples were collected and shipped to the Company's Regina pilot facility or the Integrated Demonstration Pilot (as detailed below) facility, where the daily samples were composited on a monthly basis and wet screened on 500 µm and 45 µm to obtain a minus 500 µm plus 45 µm sand fraction for heavy liquid separation. The oversize and minus 45 µm fractions were discarded, as there are no VHM present in the oversize fraction and the minus 45 µm fraction is too fine for conventional mineral processing and are not marketable. The Minerals Engineering Centre of Dalhousie University performed the heavy liquid separation using tetrabromoethane. Mineralogy determination on the sinks fraction was performed by Geochempet in Brisbane, Australia using grain-counting microscopy. Comparative chemical analyses using x-ray fluorescence ("**XRF**") on a sub-sample of the sinks were performed by UltraTrace (now Bureau Veritas) in Perth, Australia. Analytical results were compiled by the Company and overall average mineral assemblages are shown in **Table 5**.

Between 2017 and 2022, daily froth treatment samples from an oil sands operator were obtained using two automated samplers (one per process train), and collected in 1-gallon steel cans and shipped to Bureau Veritas labs in Edmonton, Alberta every 2 weeks. Initially, the samples were composited on a weekly basis and then monthly for each process train, using a rotary slurry sample divider, to avoid any sampling bias. The representative sub-samples were then cleaned using the Dean-Stark solvent distillation process and the cleaned solids were shipped to Process Mineralogical Consulting ("**PMC**") in Vancouver, BC for screening and heavy liquid separation using lithium heteropolytungstates solution at a density of 2.90 g/ml for the minus 250 µm plus 38 µm sand fraction. PMC then used a Tescan Integrated Mineral Analyzer ("**TIMA-X**") for rapid quantitative mineralogy analysis on a sub-sample of the sinks, in addition to chemical analysis using XRF to ensure correlation with the TIMA-X results and correct analyzer calibration.

Analytical results were compiled by CVW CleanTech and overall average mineral assemblage over the years and for the combined trains are compared against Syncrude and Suncor data in **Table 5**. Note that these mineral assemblages are used as a basis for engineering designs and in economic models from a mineral production perspective.

Table 5. Mineral Assemblage Results from Sampling Campaigns.

AVERAGE MINERAL COMPONENT	SYNCRUDE (2005-2014)	SUNCOR (2006-2007)	CANADIAN NATURAL HORIZON (2017-2022)
% Solids in FT Tailings	16.0	15.9	17.1
% THM content in solids	19.2	18.1	11.5
% Zircon in THM	11.0	11.1	9.7
% Rutile in THM	4.2	2.1	4.6
% Leucoxene	19.0	22.7	8.6
% Ilmenite and Altered Ilmenite in THM	17.3	27.9	6.5
% Total TiO_2 product in THM	40.5	52.7	19.7
% Pyrite in THM	9.3	3.4	21.8
% VHM in THM	51.5	63.8	29.4

3.5.2. Hydrocarbon and Water R&D Program (2008-2010)

From 2008 to 2010, CVW CleanTech's R&D programs broadened to include hydrocarbon extraction from tailings and environmental remediation. A comprehensive $7.0 million program was developed and supported by Alberta Energy with a $3.5 million grant under their Energy Innovation Fund. To develop and test its technologies, CVW CleanTech collaborated with several third-party experts including Alberta Innovates; CanmetENERGY; SGS Canada Inc. ("**SGS**"); Gas Technology Institute, Alberta and Saskatchewan Research Councils; the National Research Council; and the Universities of Alberta, Saskatchewan and Toronto. An advisory board, comprised of officials from Alberta Energy, Alberta Innovates, Alberta Environment, AER, Saskatchewan Research Council and Natural Resources Canada, was convened to monitor progress and provide independent oversite for the test program.

3.5.2.1. Bitumen Recovery

A comprehensive survey of bitumen recovery options was undertaken in 2008-2009 which included flotation, centrifugation, cycloning, filtering, flocculation and emulsion extraction. The most promising technologies, which provided high recoveries of bitumen in a quality that could be upgraded at oil sand upgraders, included flotation and solvent extraction. These technologies were advanced to a conceptual pilot at the SGS facility in Lakefield, Ontario ("**SGS Lakefield**"), testing a stage-wise process comprised of flotation followed by extraction with naphtha in a counter-current decantation flowsheet **(Figure 9)**. Tailings and naphtha were supplied by the industry and over 12,000 liters were processed in a 0.5 kg/min processing circuit. The results confirmed the utility of the flowsheet and this became the basis of the Company's Fines processing circuit to recover bitumen. The recovered bitumen quality was assessed by Schlumberger Limited, who concluded that this CVW™ bitumen was suitable for upgrading applications. Subsequent bitumen recovery testing was performed on paraffinic froth treatment ("**PFT**") tailings with similar positive results.

A similar flowsheet, that of flotation followed by naphtha extraction, was bench tested by the Gas Technology Institute to determine efficacy in mineral concentration and bitumen removal from the coarse sands fraction of FTT. The flotation circuit was based on that of the 2005 program at Mildred Lake. Testing indicated that a multistage extraction process would achieve the aspiration bitumen removal target, resulting in a heavy mineral concentrate with sufficiently low residual bitumen content to facilitate downstream mineral separation. This testing formed the basis of the Company's Coarse processing circuit.

Figure 9. CVW CleanTech's mini-pilot at SGS Lakefield in 2009, designed to test bitumen recovery from FTT using the Company's patented processes.

3.5.2.2. Naphtha Recovery

The objective of the naphtha recovery function was to remove naphtha from solids slurries to limit deposition of this solvent in downstream tailings management functions to limit the impact of subsequent anaerobic methanogenesis. The naphtha was to be recovered in a high-quality state for re-use as a solvent or as a SCO additive. CVW CleanTech engaged with Gas Technology Institute to survey potential technologies to remove and recover naphtha from FTT, including the Fines circuit raffinate and the cleaned HMC **(Figure 10)**. Identified technologies included indirect heating (thermal screw processors) and direct steam treatment in a vertical column. Testing was conducted in a bench scale vertical column design that served as the basis for the Company's current TDU design which is proprietary and includes three patents. Concurrently, a research program was started with Dr. D-Y Peng at the University of Saskatchewan to determine the vapour liquid equilibrium of tailings systems; this work defined the operating envelope of CVW CleanTech's TDU circuits.

Figure 10. CVW CleanTech's batch pilot at Gas Technology Institute to recover solvent from process tailings.

3.5.2.3. Water Recovery & Treatment

The Company retained Alberta Technology and Science Inc. to conduct a series of testing to recover water and produce thickened tailings from the CVW™ tailings streams, emanating from the flotation circuits and the fines raffinates. This testing indicated that clean water suitable for re-use could be obtained through pressure filtration followed by processing to reduce organics and dissolved solids. A process flowsheet was devised by Purifics that was tested in the Company's Integrated Demonstration Pilot.

3.6. Integrated Demonstration Pilot

From 2010 until 2014, the newly developed CVW™ hydrocarbon recovery technologies were installed at the CanmetENERGY demonstration pilot in Devon, Alberta (the "**Integrated Demonstration Pilot**"), and piloted on an integrated and continuous basis at industry-platform scale. Tailings for the Integrated Demonstration Pilot were provided by a Sustainable Technology Development Canada ("**SDTC**") consortium of Canadian Natural, Syncrude and Suncor later joined by Imperial Oil and Total E&P Canada Ltd. ("**Total E&P**"). CVW CleanTech also established a minerals facility at CanmetENERGY and conducted piloting at large-scale minerals test facilities in Brisbane, Australia. Results from this extensive demonstration piloting have been verified by oil sands operators (Canadian Natural, Suncor, Syncrude, Total E&P), engineering firms (SNC Lavalin, Worley Parsons, Stantec Consulting), and government agencies (Sustainable Development Technology Canada, Alberta Energy, Natural Resources Canada, Alberta Innovates). Piloting results confirm hydrocarbon recoveries and commercial quantities of high quality VHM (zircon and titanium), improved tailings remediation and improved quality water.

CVW CleanTech executed the integrated piloting activity to commercially demonstrate the CVW™ suite of technologies, designed to remediate oil sands FTT providing environmental benefits and resource commodity values. This Integrated Demonstration Pilot comprised of a Concentrator Plant (the Fines and Coarse circuits as well as the solvent recovery circuits), tailings management processing, water recovery and treatment and minerals production, is a commercial demonstration of the CVW™ technologies operated at the Integrated Demonstration Pilot (**Figure 11**). The Integrated Demonstration Pilot was operated at a nominal 1/2000th scale, select pilot units including the dynamic mixers were operated at 1/20th scale and front-end cyclone operations and minerals testing was conducted at up to full commercial scale. The Integrated Demonstration Pilot has generated the technical and commercial data required to implement this important technology at a commercial scale throughout the oil sands industry.

The Integrated Demonstration Pilot was a $26 million demonstration pilot conducted under the auspices of a project consortium including SDTC, the Government of Alberta, Canadian Natural, Suncor, Syncrude and Sojitz Corporation. The project was funded 60% by CVW CleanTech, 30% by SDTC and 10% by the Alberta Government. Furthermore, the National Research Council provided Industrial Research and Assistance Program funding. The industrial members of the consortium provided tailings from their commercial operations and lent valuable technical cooperation to the program. The program is described in three major phases, (1) engineering, construction and installation of the Integrated Demonstration Pilot; (2) optimization and operation of the Integrated Demonstration Pilot utilizing Canadian Natural, Suncor and Syncrude FTT; and (3) production of bulk quantities of cleaned HMC for full scale mineral testing in Australia. The first two phases were completed in 2010-2011 and the third phase was completed between the fall of 2012 and winter of 2014.

Over the duration of testing, 525 material balances (29 weeks of operation) were conducted with over 34,000 samples collected and analyzed. Analyses were conducted by Maxxam Analytics International Corporation using accepted American Society for Testing and Materials ("**ASTM**") procedures. Process engineering data, including flow rates, temperatures and pressures, were captured in a data logging system at five second intervals. Test data and results were reviewed in detail by the operators and other stakeholders. Consortium member oil sands operators, including Canadian Natural, Suncor and Syncrude, independently verified select results and calculations. The operations provided confidence in the tested technologies. Further details are provided in the **Appendix**.

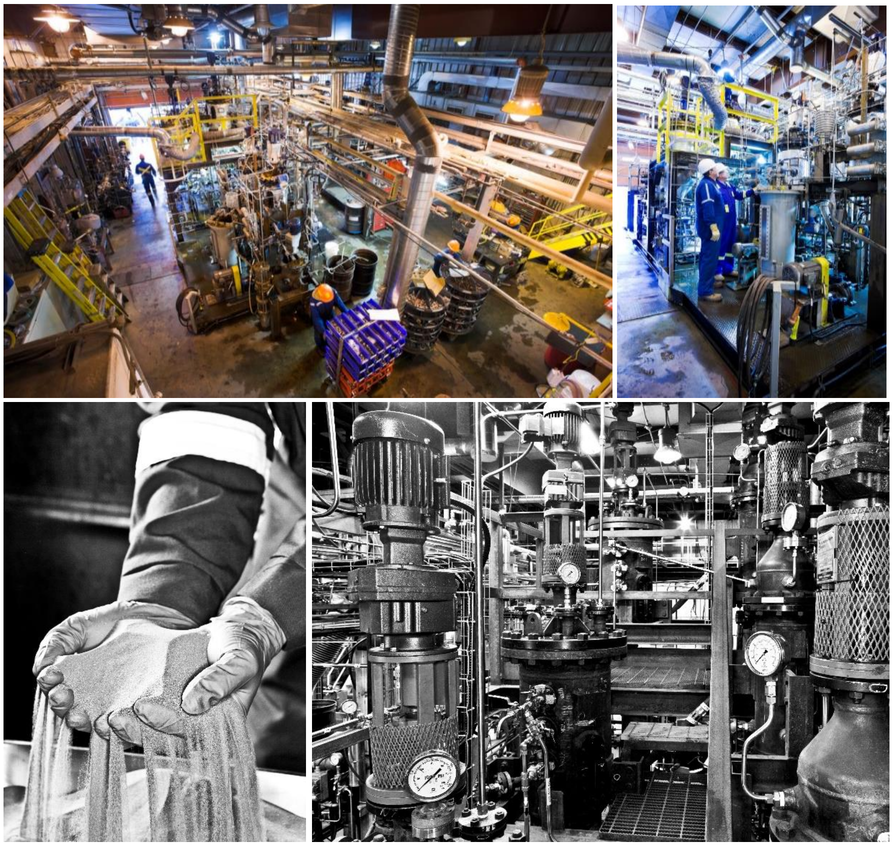

Figure 11. CVW CleanTech's Integrated Demonstration Pilot. Clockwise from top-left: panoramic view of installed Integrated Demonstration Pilot; TDU; solvent extraction circuit; produced clean mineral concentrate.

3.6.1.1. Bitumen Recoveries & Qualities

The Concentrator Plant circuitry processed approximately 380 m^3 of naphtha-based FTT over Phase 2, achieving the maximum continuous operational length available at the CanmetENERGY facility (Moran & Doiron, 2012). In Phase 3, approximately 2.4 tonnes of clean HMC was produced utilizing a debottlenecked Coarse circuit (Moran & Doiron, 2014). The CanmetENERGY froth treatment facility was operated at its design capacity of ~5-10 kg/min.

The primary cyclone circuit, which separates the fines slurry from the coarse slurry was operated as a full-scale circuit processing about 30 tonnes of FTT per hour. The separated slurries were then stored in tankage (fines slurry) or drums in advance of processing in the Concentrator Plant. The target cut ratio of 10-20% of feed slurry reporting to the coarse slurry was achieved during the testing (**Figure 12**). Under these design conditions, approximately 15% of the bitumen and 30% of the mineral solids report to the Coarse circuit feed.

The Fines module consisted of a flotation circuit followed by a two-stage solvent extraction mixer-settler circuit in a counter current decantation arrangement. Following commissioning with FTT and initial operator control learnings, this process module ran nearly without incident and improved performance over the testing duration. The flotation cell performance was excellent, recovering high values of bitumen, with a conservative average greater than 94% (94.1 ± 1.5%, range of ~90%-99%), over the steady operational period of the first two milestones (**Figure 13**). The performance was achieved by controlling the mass take to the froth. The froth grade varied somewhat with bitumen feed concentrations and often approached the design concentration of 5%.

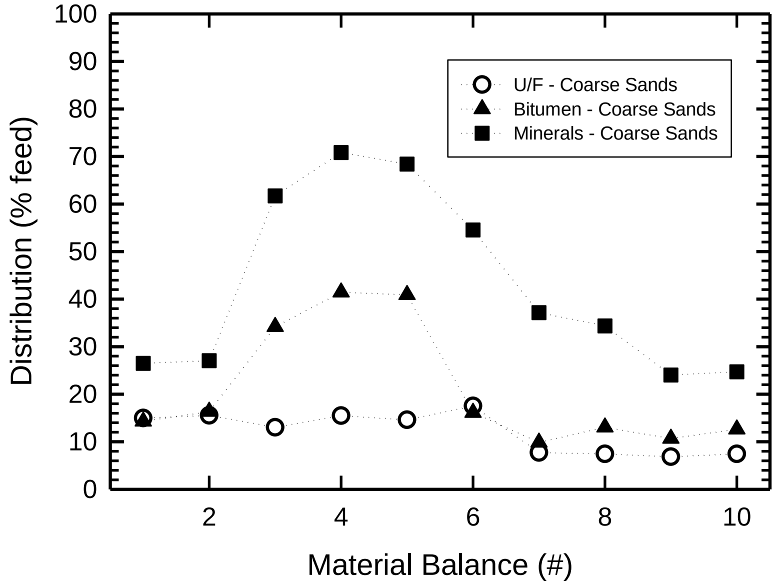

Figure 12. Distribution of slurry, bitumen and solids into the coarse sands stream in the primary cyclone module during the period of July to August, 2010 at the Integrated Demonstration Pilot.

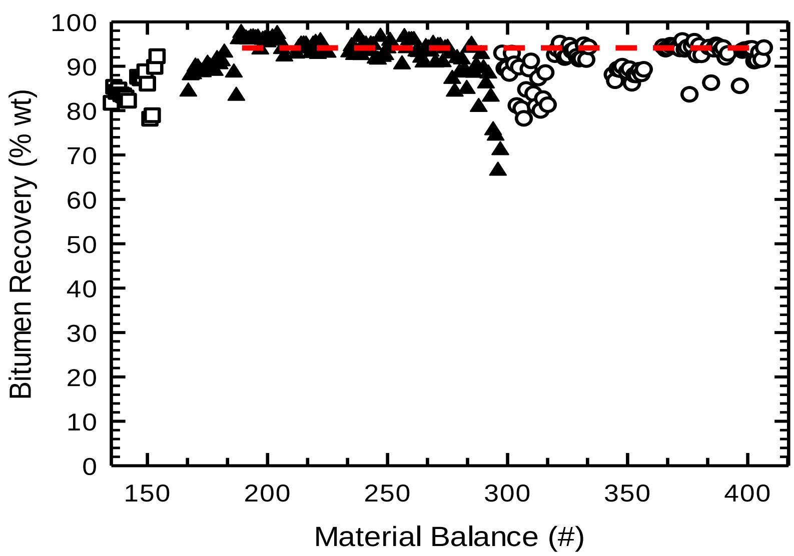

Figure 13. Bitumen recovery performance of the Fines flotation circuit at the Integrated Demonstration Pilot at CanmetENERGY. The symbols represent operations utilizing tailings supplied by different oil sands operators.

The produced bitumen froth was then sent to the Fines solvent extraction circuit for further processing to a diluted bitumen product that could serve as feedstock for downstream upgrading operations. The solvent-based extraction circuit proved to be quite robust and the operating window within solvent dilution ratio, temperature and mixing intensity was explored. The Fines solvent extraction performance over the steady piloting period was typified by an average bitumen recovery of 90% (90.3±4.8%, range ~75%-99%) over the duration of steady operation (**Figure 14**). These recoveries have been filtered to eliminate outliers characterized by closure errors greater than 10% and were achieved at the target solvent dilution ratio measured as a naphtha-to-bitumen ratio of approximately three to five.

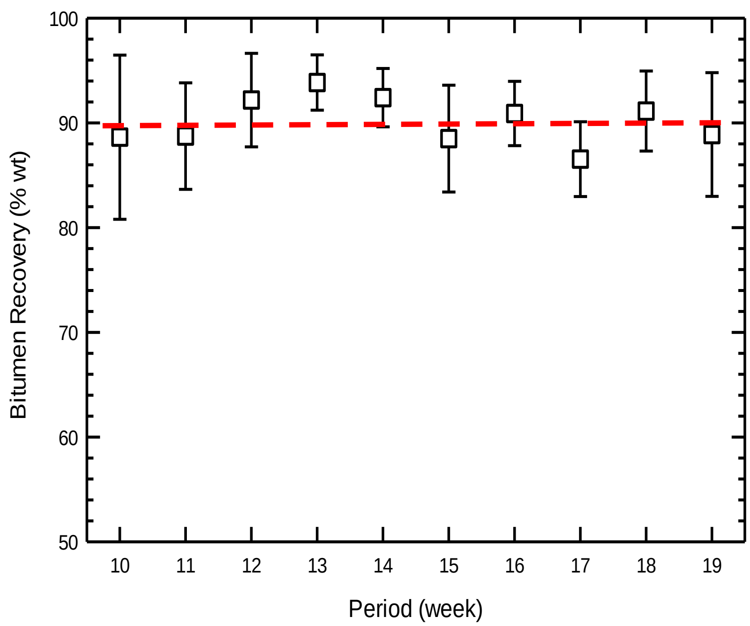

Figure 14. Bitumen recovery performance of the Fines solvent extraction circuit at the Integrated Demonstration Pilot at CanmetENERGY. The error bars represent the standard deviations of measurements within the period.

The overall bitumen recovery of the Fines circuit can be ascertained as the product of the flotation and solvent extraction circuits. In doing so, the flotation data was averaged on a weekly basis for consistency with the solvent extraction performance data. The corresponding cumulative error is estimated as the square root of the sum of the relative squared standard deviations for each of the flotation and solvent extraction data measured over the period. The Fines circuit overall bitumen recovery is calculated at ~85% (86.1% ± 4.9%, range ~75-99%) over the steady operation period of Phase 2 of the Integrated Demonstration Pilot (**Figure 15**). The quality of the produced diluted bitumen has met or exceeded the specification of 3% water and solids at solvent dilutions of commercial interest, measured as a naphtha-to-bitumen ratio of ~ 3-5. This is within the targeted dilution range for typical downstream oil sands upgrading feedstock. The 'raffinate' from the extraction operation contains residual amounts of naphtha that must be removed in the CVW™ distillation circuit.

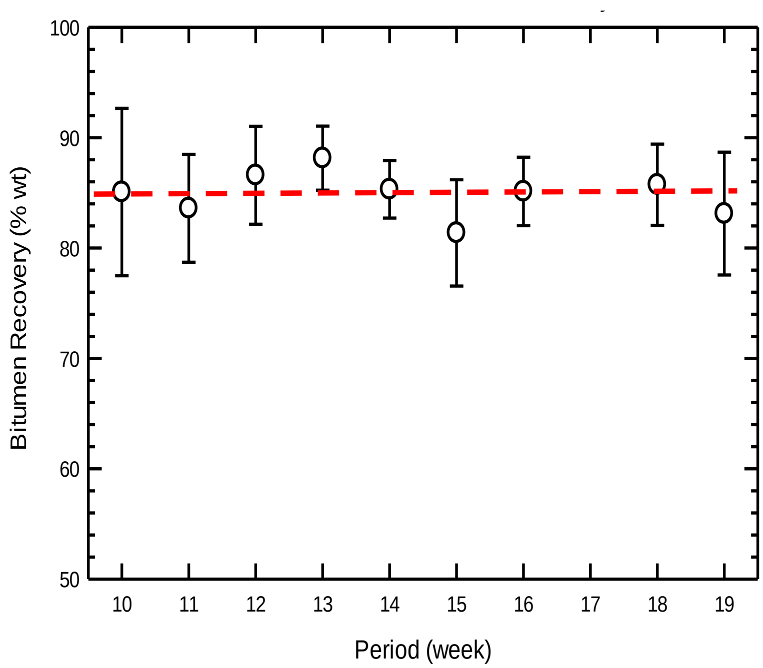

Figure 15. Overall bitumen recovery performance of the Fines circuit at the Integrated Demonstration Pilot at CanmetENERGY. The error bars represent the cumulative error of measurements within the period.

The quality of the produced bitumen from the Fines circuit (and Coarse circuit, as described below) conforms with key specifications of Athabasca bitumen, including that supplied by industry in partial fulfillment of in-kind support under the SDTC arrangement (**Table 6**). The suitability of bitumen produced in this Integrated Demonstration Pilot for primary upgrading is important from a comparative perspective with those produced in commercial mining and extraction facilities by oil sands operators.

Following ASTM D5002, density was measured at 40°C, 60°C and 80°C for both the 200°C and 343°C bitumen cuts obtained from the bitumen recovery module of the Integrated Demonstration Pilot. These measured values were extrapolated to 15°C for comparison with the AER convention and literature values. The 200°C bitumen cut has a lower density profile compared to that of the 343°C cut as expected, and CVW™ bitumen densities (and corresponding API gravities) are consistent with Athabasca bitumen.

Crude hydrocarbons are, by their nature, largely composed of carbon and hydrogen. Certain aspects of their processability are revealed by analyses of such. ASTM D5291 has been utilized to determine the carbon, hydrogen and nitrogen compositions of the bitumen produced in the bitumen recovery circuit. The produced bitumen appears to be comprised of amounts of carbon, hydrogen and nitrogen that are consistent with Athabasca bitumen, which is typically ~83% carbon and 10-11% hydrogen by weight.

As bitumen is a dense oil with a rather high molecular weight distribution, it needs to be first processed in thermal cracking operations to produce distillates that can then be converted in secondary upgrading operations. A key characteristic of these dense crude oils is their asphaltenes content and carbon residue tests which are an indication of coke forming propensity. In this study, asphaltenes content was determined by a 'Syncrude Method' that is based on pentane insolubility (Starr & Bulmer, 1979) and ASTM D4530 was employed to determine the microcarbon residue ("**MCRT**") of the bitumen to assess 'cokability'.

The content of metals, vanadium and nickel in particular, are problematic in the upgrading of bitumen due to their ability to poison catalysts in secondary treating. In addition to others, vanadium and nickel content were assessed for the bitumen cuts and found to be below norms for Athabasca bitumens.

Table 6. Quality of bitumen recovered from FTT by CVW^{TM} technologies compared to product bitumen obtained from a commercial oil sands plant. Sources & notes: a- (Speight, 1991); b – (Bichard, 1987); c - (Dahbag, et al., 2020); d – (Masliyah, Czarnecki, & Xu, 2011); ** CCR; *** dry basis – estimate of typical coker feed specifications.

MEASUREMENT	CVW^{TM} BITUMEN 200°C	CVW^{TM} BITUMEN 343°C	ATHABASCA BITUMEN 200°C	ATHABASCA BITUMEN 343°C	LITERATURE VALUES
Density (kg/m³)	999.7 ± 5.1	1024.8 ± 1.3	1026.2	1041.2	1015[d]
API (°)	9.28	6.4	6.4	4.4	7.5
H/C (atomic)	1.54 ± 0.08	1.49 ± 0.07	1.49	1.47	1.49-1.56[a,b]
Asphaltenes (wt%)	17.7 ± 3.2	20.2 ± 3.5	20.9	21.6	15-24[a,b]
MCRT (wt%)	12.6 ± 0.7	14.8 ± 0.6	15.3	17.0	13.6-18.9[**, a,b]
Nickel (ppmw)	8.4 ± 4.4	15.6 ± 11.9	5.81	11.1	50-300[a,b]
Vanadium (ppmw)	98.6 ± 48.1	179.1 ± 26.7	90.8	101	250-400[a,b]
Sulphur (wt%)	4.7 ± 0.1	5.2 ± 0.1	4.68	4.84	1-5[a,b]
TAN (mg KOH/g)	2.39 ± 0.10	2.43 ± 0.33	2.48	2.75	3.8[c]
Ash (wt%)	0.18 ± 0.09	0.22 ± 0.13	1.2	1.2	1.5[***]

Other properties such as total acid number ("**TAN**"), sulphur and ash content of bitumen are important to understand from an industrial perspective. High sulphur content in oils limits marketability and, as such, requires removal in upgrading operations. Ash serves as a foulant in upgrading, perhaps more so in secondary processes involving catalysts. The acid content in bitumen is not desirable due to the corrosive effects on process equipment. The TAN (ASTM D664), sulphur content (ASTM D4294) and ash content (ASTM D482) were evaluated for the bitumen cuts to understand bitumen quality. While TAN and sulphur content were consistent with commercial bitumen, the ash content was notably lower which further indicated the high quality of CVW^{TM} produced bitumen.

3.6.2. Mineral Concentrate Production and Cleaning

Coarse sands, separated from the FTT in the CVW^{TM} primary cyclone circuit, were processed in the HMC production (Coarse) module over a ~15 week duration of testing in Phase 2 of the Integrated Demonstration Pilot and throughout Phase 3 operations, in which bulk volumes of clean mineral concentrate was produced for subsequent processing in Australia.

The Coarse module consists of a two-stage flotation circuit in a rougher-scavenger arrangement followed by a three-stage, mixer-settler froth cleaning circuit utilizing a solvent. The bulk flotation operation, utilizing a frother and collector, rejects clean silaceous mineral mass and produces a HMC enriched in valuable critical minerals. Enriching the critical minerals into a concentrate reduces the size of the subsequent Mineral Separation Plant. Then the HMC is 'cleaned' of bitumen in a three-stage, mixer-settler solvent-based washing circuit in a counter-current decantation arrangement to minimize naphtha consumption. Such cleaning is necessary to avoid fouling in downstream mineral separation operations and improve mineral recoveries in these circuits. The objective of this processing circuit is to recover over 90% of contained valuable minerals into a cleaned heavy mineral concentrate characterized by a THM content of 50% and residual bitumen content of less than 0.5% weight on a dry solids basis.

The unit operations comprising the Phase 3 production run (2012-2013) largely exceeded planned performance indicators based on the 2010 to 2011 demonstration campaign experience. A total of 2.4 tonnes of cleaned HMC was produced over a period of nine weeks of steady operations in Phase 3. Weekly HMC production ranged from about 175 kg, representing about 60% of the nameplate capacity of the debottlenecked plant, to 360 kg and ~110% of the nameplate rate. The mass average weekly HMC production was 258 kg; this represents a 3.5 fold increase compared to the Coarse circuit operation in Phase 2 (~70 kg/week).

The recovery of critical minerals is a function of the froth produced in the flotation operation. The recovery performance for zircon as a function of froth mass yield in the bulk flotation operation is shown (**Figure 16**). In this graphic, a broken red curve is used to indicate the trend. The recovery of heavy minerals stabilizes at froth mass takes above about 40%. The CVW™ bulk flotation design basis is set at about 50% froth mass yield, where zircon recovery to froth approaches 95% at 94.4% ± 4.2%. Also shown is historic data from the Company's earlier testing efforts. This includes the Phase 2 performance during the Integrated Demonstration Pilot (open red circles), the 1/20th scale 2006 Mildred Lake pilot (solid red triangle) and bench scale testing (open blue triangles).

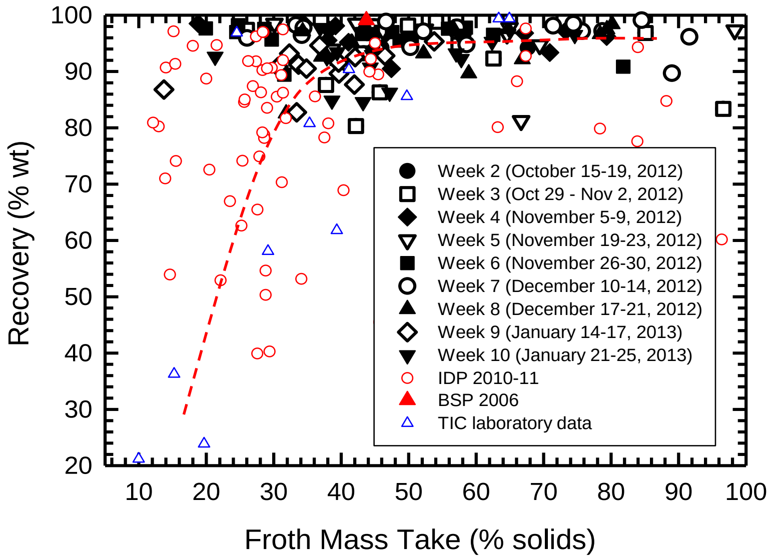

Figure 16. Recovery of zircon from the coarse sands fraction utilizing the bulk flotation circuit of CVW™ technology during Phase 3 of the Integrated Demonstration Pilot. Also shown is Phase 2 performance, Mildred Lake BSP pilot results and CVW CleanTech laboratory testing.

The THM content of the produced heavy minerals concentrate was found to be 58.7% ± 7.1% and meets the project specification (**Figure 17**). Of the heavy minerals fraction, the zircon and titanium-bearing constituents are well represented at 13.3% ± 3.7% and 32.5% ± 9.0%, respectively, and suggest an attractive concentrate. Further, the particle size distribution of the produced HMC was within ranges observed in previous campaigns, with a d_{50} of ~105 microns. The contaminants concentrations in the produced HMC, including silica, ferric iron and alumina, are within anticipated values and are manageable with the Company's downstream minerals dressing practices.

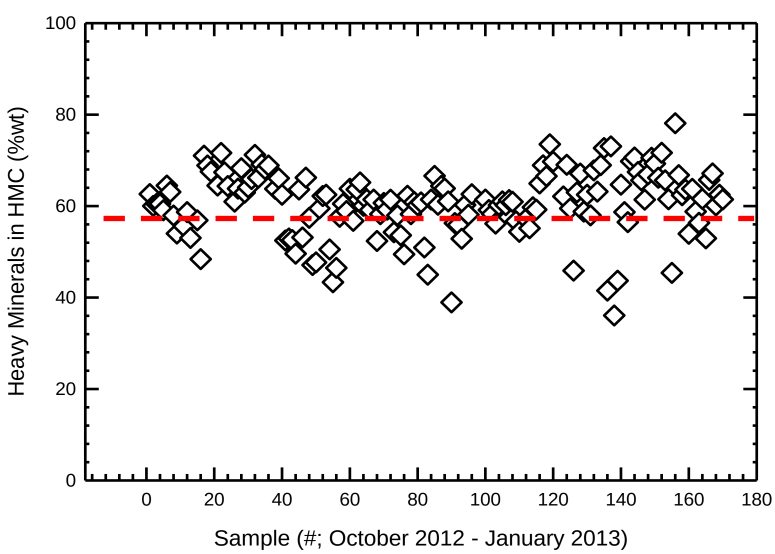

Figure 17. Quality of heavy mineral the coarse sands fraction to heavy mineral froth in the flotation circuit of CVW™ technology during Phase 3 of the Integrated Demonstration Pilot.

In addition to critical minerals, the bulk flotation operation co-produces bitumen from the coarse sands fraction at 93.8 % ± 2.3% of the bitumen contained in the coarse sands feed to the flotation circuit (**Figure 18**). This bitumen reports to the froth with the HMC and must be removed prior to further mineral enrichment.

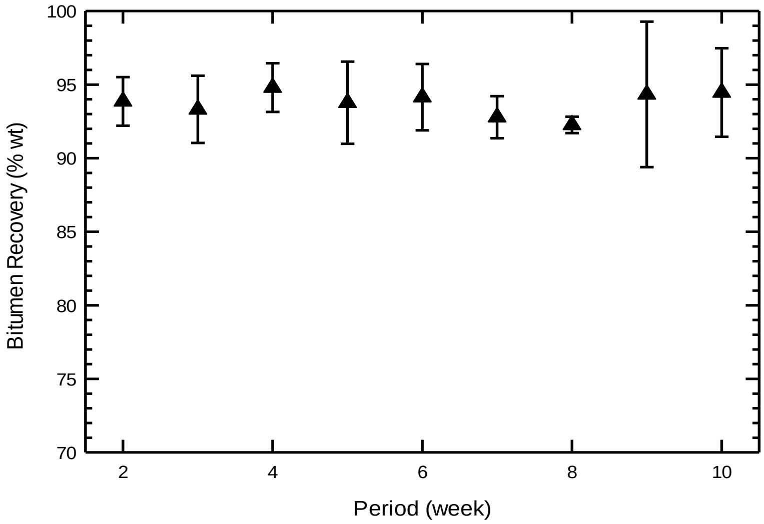

Figure 18. Recovery of bitumen from the coarse sands fraction to heavy mineral froth in the flotation circuit of CVW™ technology during Phase 3 of the Integrated Demonstration Pilot.

The HMC produced in the flotation circuit is then cleaned using naphtha to extract the bitumen resulting in a cleaned HMC that contains trace amounts of bitumen and some residual naphtha. The subsequent solvent extraction operation recovered 92.6% ± 4.6% of the HMC froth bitumen (**Figure 19**). This recovered bitumen met coker-feed quality specifications within the target dilution range (c.f., **Table 6**). In the Coarse circuit extraction unit, a three-stage countercurrent decantation flowsheet was employed to provide enhanced bitumen recovery relative to the two-stage in the Fines circuit, owing to the stringent residual bitumen specification (0.5 wt% on dry solids basis) required of the HMC to facilitate effective downstream processing in the Mineral Separation Plant. The performance in the Coarse solvent extraction circuit was only marginally better than that of the Fines circuit. The extra stage provides a buffer against higher than anticipated incoming bitumen concentrations, as was experienced in the Integrated Demonstration Pilot in the Fall of 2012. The net bitumen recovered from the Coarse circuit, the product of the flotation and solvent extraction operations, was 86.2% ± 6.1%. The diluted bitumen recovered in this circuit is blended with the diluted bitumen produced in the Fines circuit and the comingled stream represents the CVW™ bitumen production.

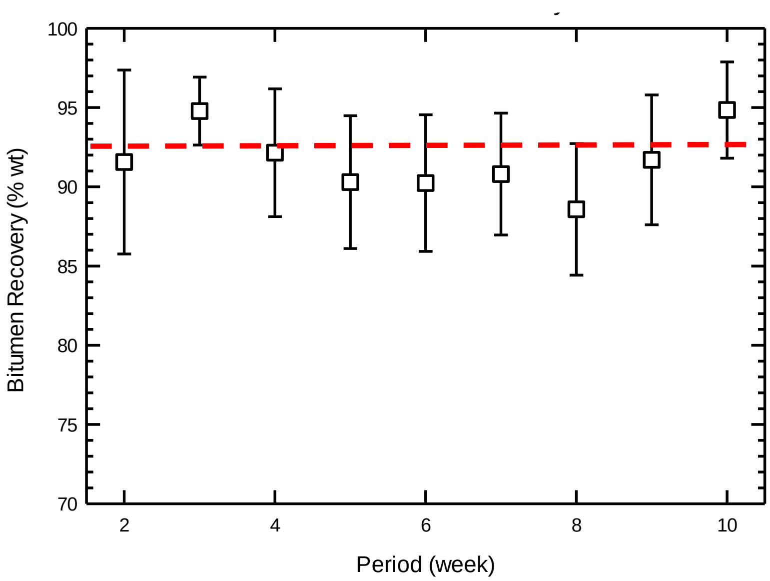

Figure 19. Recovery of bitumen from the heavy mineral froth in the HMC production module solvent extraction circuit of CVW™ technology during Phase 3 of the Integrated Demonstration Pilot.

While the recovered bitumen from the coarse tailings represents a valuable commodity that can be upgraded to SCO, a key purpose of the Coarse circuit is to remove bitumen from the produced HMC. The Integrated Demonstration Pilot performance indicated that residual bitumen residing with the HMC exceeded the Company's specification (of 0.5% of dry solids weight) at 0.48% ± 0.12% during Phase 3 operations (**Figure 20**). During Phase 2 of operations, the residual bitumen content in the HMC was ~0.35% and exceeded performance expectations. On start-up of Phase 3 operations, the coarse sands feed was characterized by high bitumen concentrations that could, at times, reach 20% (slurry basis). A blending strategy was adopted to reduce the bitumen variability in the feedstock and the Coarse circuit processing responded well. While the average bitumen concentration in the 2.4 tonne HMC sample prepared in Phase 3 was higher than that observed in Phase 2, this was attributed to the significantly higher throughput achieved in this circuit and higher than design feed bitumen concentrations. The positive processing response of this fine-grained HMC, even at residual bitumen concentrations as high as 0.7%, was confirmed in extensive gravity tabling that revealed unique behaviors that could be exploited for enhanced recovery potential.

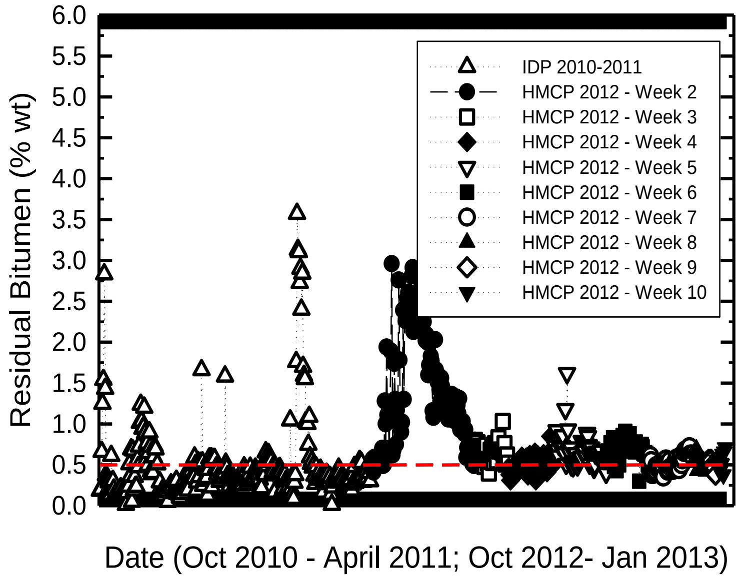

Figure 20. Residual bitumen in heavy mineral concentrate produced at the Integrated Demonstration Pilot during Phase 2 (open triangles; 2010-2011) and Phase 3 (2012-13).

3.6.3. Naphtha Recovery & Qualities

The solvent recovery circuitry consists of two vertical column TDUs, one to process tailings from the bitumen recovery (Fines) circuit and one for the clean HMC from the HMC production (Coarse) circuit, with associated overhead condensers. TDUs achieve naphtha removal through steam distillation of the tailings. The performance of the TDU circuits has exceeded expectations with average naphtha recovery, averaging in excess of 98% (98.3% ± 2.3%, range of 96% to 99.5%) at design conditions (**Figure 21**). Phase 3 naphtha recovery from cleaned HMC is indicated by the black and white symbols while that of Phase 2 is indicated by red triangles (Fines TDU, closed symbols; Coarse TDU, open symbols). The performance observed in Phase 3 was enhanced relative to Phase 2 as a result of technology learnings and higher production rates.

The performance of conventional naphtha recovery circuits at commercial oil sands sites, referred to as naphtha recovery units ("**NRU**") is indicated in the figure as grey 'x' symbols. The performance of CVW CleanTech's TDU is significantly greater than that of current commercial equipment. The current NRU vessels operate within AER guidelines that stipulate an operator can lose no more than about four barrels of naphtha per thousand barrels of bitumen produced. This naphtha loss intensity ("**NLI**"), along with a curve representing 3 bbl/kbbl loss is shown in the graphic, creating a 'band' of typical NRU performance. An equivalent NLI curve for CVW CleanTech's TDU integration indicates a NLI of less than 0.7 bbl/kbbl (approximately 0.5 bbl/kbbl; broken green curve), an improvement of about 88% compared to regulated performance.

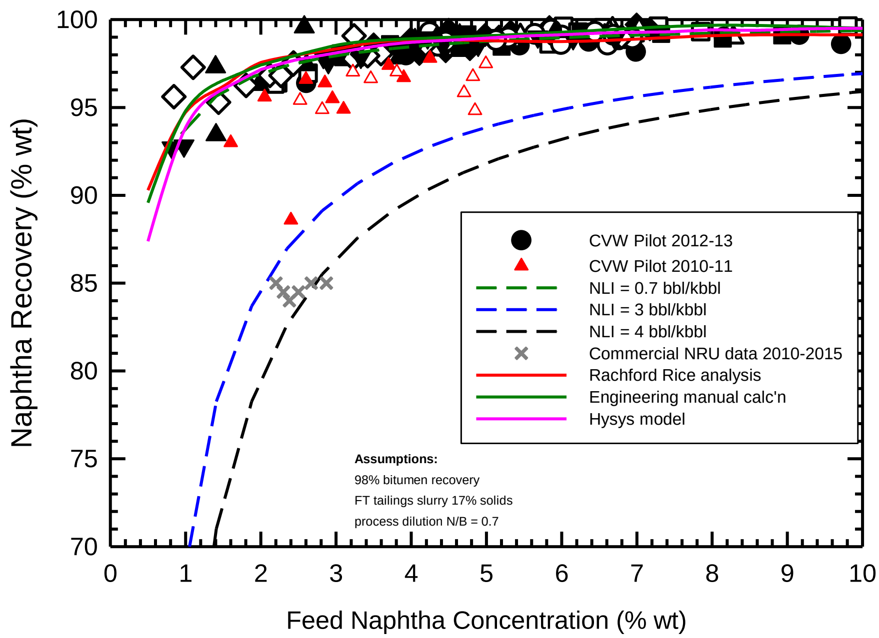

Figure 21. Naphtha recovery from CVW CleanTech's fines raffinate and cleaned HMC during Phase 2 (red triangles; 2010-2011) and cleaned HMC during Phase 3 (2012-13). Industry data, analytical calculations and modelling results are also shown.

The Company has conducted extensive engineering calculations to model the performance of the TDUs using flash calculations (Rachford Rice analysis) and enthalpy balances (solid green curves). These calculations are founded on tailings vapour liquid equilibrium thermodynamic calculations, performed on Integrated Demonstration Pilot TDU feedstocks, by Ding-Yu Peng from the University of Saskatchewan (Moran, 2019). Further, the Company has modelled the TDU process with established process modelling software (Aspen Hysys V. 10) to validate the analytical calculations (solid pink curve, **Figure 22**) The agreement with pilot data over a range of feed naphtha compositions is excellent, suggesting a strong understanding of the fundamental thermodynamics governing the tailings distillation process. Further computational fluid dynamic modelling was conducted to assist with the scaling of the units during the CVW CleanTech Horizon engineering programs (see **§ 3.7**).

The residual naphtha content residing in the TDU underflows (Fines tailings and cleaned HMC) was monitored for environmental and safety purposes. Naphtha deposited into tailings ponds serves as the substrate for methanogenic fermentation resulting in the fugitive release of significant volumes of methane at an oil sands mining site. Further, to ensure a safe operating environment in the MSP, avoiding additional capital and operating expenditures related to electrically classified areas, it is important to ensure residual naphtha content in cleaned HMC meets specifications for safe operation conditions in the downstream Mineral Separation Plant. The residual naphtha content in TDU underflows is shown in **Figure 22**.

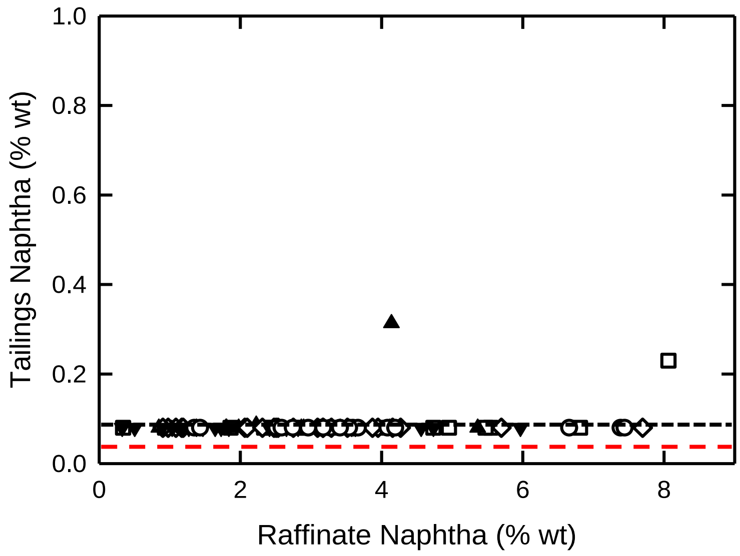

Figure 22. Typical residual naphtha content in CVW CleanTech's TDU underflows as a function of TDU feed naphtha concentration. The commercial quality assurance minimum reporting level is shown at 0.08 wt% (broken black curve) and the unconstrained industry measurement (0.04 wt%; broken red curve). The data indicates operations with different FTT feedstocks.

In this figure, the residual tailings naphtha concentration is 'pinned' at 0.08 wt%. This is a result of the reporting restrictions of the analytical contractor and the ISO reporting accuracy of their methodology. An Integrated Demonstration Pilot consortium member – an oil sands operator – conducted their own analysis to understand the unconstrained residual naphtha concentration in the CVW™ tailings. Their work indicated that the residual naphtha concentration was significantly lower than the ISO constrained reporting value, at typically 0.04-0.05 wt%. This result suggests an enhanced utility of the TDU regarding naphtha recovery performance – in addition to economic values ascribed to recovered naphtha as a valuable commodity, the CVW™ technology enables enhanced environmental and safety benefits.

The recovered naphtha condensed from the TDU overheads was compared to the process feed naphtha over a range of physical and chemical properties to assess its quality. Simulated distillations of the head solvent and produced solvent indicate near identical thermal behaviors (**Figure 24**, indicating that the TDUs are capable of capturing the full range of naphtha components. A similar comparison of naphtha components, based on PIONA analysis, was conducted to assess the relative hydrocarbon character of the naphtha recovered in the TDU circuits (**Figure 23**).

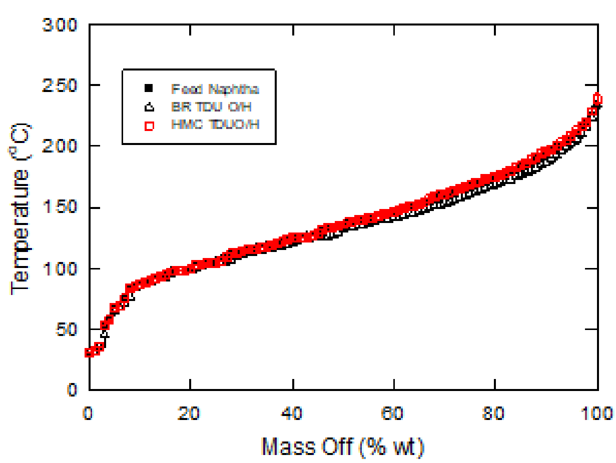

Figure 24. Comparison of the simulated distillation (ASTM D2887) behavior of head naphtha and that produced from the TDU circuits of the Integrated Demonstration Pilot during Phase 2 of plant operations.

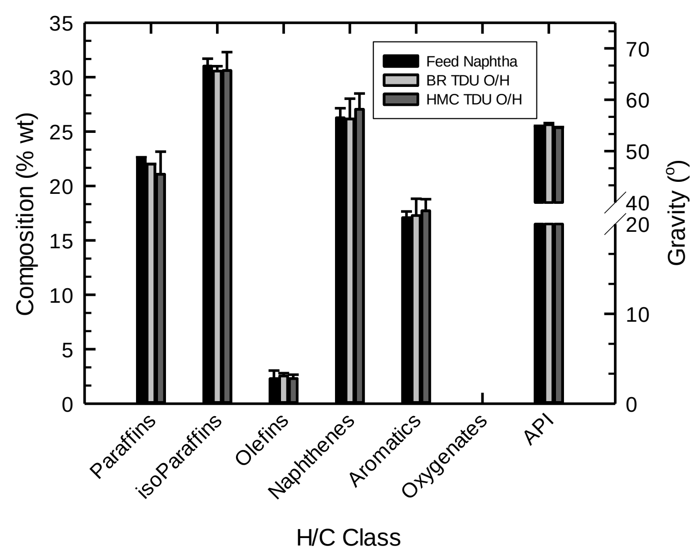

Figure 23. Composition of head solvent (jet B naphtha) and produced solvent from the Fines (BR) and Coarse (HMC) TDU operations during Phase 2 of the Integrated Demonstration Pilot. The values represent the average composition over several measurements, with error bars indicating the standard deviations.

The agreement amongst hydrocarbon classes – paraffins, iso-paraffins, olefins, naphthenes and aromatics – between head samples and those recovered by the TDU indicates that the process pulls out the entire suite of naphtha components. Further, the API gravity of the recovered samples was identical to that of the host naphtha.

3.6.4. Minerals Recoveries & Qualities

Metallurgical process development test work programs completed in 2010, 2011 and 2012 utilizing full scale, scalable and bench scale equipment resulted in the development of process flow diagrams and metallurgical confirmation test programs. In part, test work conducted at Integrated Demonstration Pilot indicated the potential to recover high values of fine-grained zircon (Moran & Doiron, 2013). Testing conducted in parallel with IHC Robbins in Brisbane, Australia was executed to develop a viable mineral separation process for the Mineral Separation Plant (Kruger, 738-PM-REP-0000-8002 Rev D, 2014).

CVW CleanTech provided IHC Robbins with a bulk sample post bitumen removal for the completion of metallurgical confirmation test work of the developed process and methodology, utilizing full scale or scalable equipment. The process utilized conventional mineral dressing equipment, including gravity spirals, wet shaker tables, high intensity wet magnets, high tension rolls and dry magnets. A flotation circuit was used to remove pyrite.

Characterization of the nominal 2 tonne sample indicated it to contain 49.9% heavy mineral, no oversize (+1.0mm) and 9.9% slimes (-38 micron). Chemical and mineralogical analyses indicated critical minerals to consist predominantly of titanium bearing minerals and zircon accounting for 53.5% of the THM with the remainder consisting of alumino-silicates, pyrite and tourmaline. As received material containing residual bitumen levels of <0.5% was processed readily through the developed process indicating the material to be sufficiently clean to facilitate effective recovery of VHM.

Table 7. Heavy mineral – XRF analyses of the bulk HMC sample produced at CanmetENERGY and supplied to IHC Robbins during the Integrated Demonstration Pilot.

ASSAY	TiO2 %	Fe2O3 %	SiO2 %	Al2O3 %	Cr2O3 %	ZrO2+HfO2 %	P2O5 %	U XRF ppm	Th XRF ppm	SO3 %	CeO2 %
Heavies	29.5	22.0	17.4	7.7	0.2	8.9	0.7	108	286	22.1	0.3

Processing inclusive of minor variations and the development of an appropriate wet zircon process produced a primary zircon product, secondary zircon concentrate and titanium concentrate (“**HiTi**”) product of acceptable qualities. Detailed chemical analyses for the produced products, compared to previous IHC Robbins test programs 408B and 476 are included in the Tables below. The primary zircon and HiTi were further calcined to reduce sulphur levels to < 0.05%.

Table 8. XRF analyses of primary grade zircon produced from the CanmetENERGY bulk HMC sample and supplied to IHC Robbins during the Integrated Demonstration Pilot. Comparisons to previous testing programs ‘408B’ and ‘476’ are referenced.

ASSAY Primary Zircon	TiO2 %	Fe2O3 %	SiO2 %	Al2O3 %	ZrO2+HfO2 %	P2O5 %	U XRF ppm	Th XRF ppm	CeO2 %
408B	0.07	0.09	32.2	0.08	67.2	—	336	159	—
476	0.10	0.10	32.4	0.13	66.5	0.1	321	152	0.01
738	0.15	0.08	32.4	0.09	66.6	0.2	331	137	0.02

Table 9. XRF analyses of secondary zircon concentrate produced from the CanmetENERGY bulk HMC sample and supplied to IHC Robbins during the Integrated Demonstration Pilot. Comparisons to previous testing programs '408B' and '476' are referenced.

ASSAY Secondary Zircon Concentrate	TiO2 %	Fe2O3 %	SiO2 %	Al2O3 %	ZrO2+HfO2 %	P2O5 %	U XRF ppm	Th XRF ppm	CeO2 %
408B	—	—	—	—	—	—	—	—	—
476	1.47	0.21	31.7	1.1	63.4	0.4	527	288	0.01
738	2.35	0.25	30.3	0.3	62.9	0.9	607	352	0.04

Table 10. XRF analyses of HiTi produced from the CanmetENERGY bulk HMC sample and supplied to IHC Robbins during the Integrated Demonstration Pilot. Comparisons to previous testing programs '408B' and '476' are referenced.

ASSAY HiTi Product	TiO2 %	Fe2O3 %	SiO2 %	Al2O3 %	Cr2O3 %	ZrO2+HfO2 %	P2O5 %	U XRF ppm	Th XRF ppm	CSO3 %
408B	—	—	—	—	—	—	—	—	—	—
660 (Ex 476)	85.3	3.5	6.1	1.4	0.12	0.4	0.2	48	100	2.4
738	89.2	3.1	3.5	1.1	0.19	0.2	0.1	50	76	0.6

Overall zircon recovery calculated on a stage-by-stage basis was 57.4% for primary zircon and 5.6% for secondary zircon concentrate for an overall zircon recovery of 63%. Overall zircon recovery achieved for project 738 was 15.1% higher than that achieved for initial process development test work (408B) and deemed appropriate based on heavy mineral mineralogy (53.5% ilmenite, leucoxene, rutile, zircon) and multi-stage processing (six main processes) to produce products of acceptable quality. Improved overall zircon recovery as compared to projects 408B and 476 can be attributed to the inclusion of the pyrite flotation process prior to the concentrate upgrade process, resulting in improved metallurgical performance of the concentrate upgrade process and the primary dry process.

Overall, zircon recovery is based on actual test work and excludes recirculation and semi-processed streams. The inclusion of these through mathematical modelling is required to calculate an optimum projected recovery. Optimization activities were conducted during subsequent engineering efforts resulting in zircon production to a 75% concentrate with the potential of 87% (86.1% ± 1.2%, range of ~82% - 90%) recovery in a reworked flowsheet.

Overall titanium mineral recoveries, although low, are deemed appropriate given that HiTi is a by-product from the production of zircon, with the CVW CleanTech focus being zircon production. Overall titanium mineral recovery data for a HiTi product only included 1.8% ilmenite, 10.6% leucoxene and 22.7% rutile/anatase. IHC Robbins noted that an option to produce a lower grade HiTi product (TiO_2 >80%) would increase titanium mineral recoveries but is subject to further testing and market suitability of such a product. Such activities were undertaken by CVW CleanTech during project engineering exercises from 2020 to 2021, resulting in significantly higher recoveries of 73% (68.2% ± 6.5%, range of ~50% - 88%) titanium minerals to a new HiTi product referenced as 'chloride ilmenite'. These were achieved by replacing select equipment and tuning operations to titanium minerals recovery.

3.6.5. Tailings Management

During the period from August 2010 to December 2010, CanmetENERGY carried out a pilot-scale test program for CVW CleanTech at its Devon research centre (Mikula, 2010). CVW™ tailings were supplied 'live' from the CP operated in an adjacent building at the CanmetENERGY facility. The goal was to evaluate physical separation technologies aimed at dewatering and consolidating FTT having significantly reduced fractions of hydrocarbon and valuable minerals. A series of bench-scale and continuous pilot-scale evaluations were carried out to understand the characteristics of the resulting tailings stream and compare the performance to that of conventional fluid fine tailings using a variety of tailings management technologies, including centrifugation, rim ditching, and thin lift dewatering.

CVW^{TM} tailings were characterized by Dean-Stark analysis, sedigraph, and x-ray diffraction to understand the bitumen content, particle size distribution, and mineral makeup of the tailings stream. Tailings samples were collected prior to each experiment and combined to assess the average tailings characteristics throughout the test program. The tailings averaged 11 wt% solids with 1 wt% hydrocarbon. The particle size distribution showed on average 73% passing 44 µm and 30% passing 2 µm. The mineral analysis showed the predominance of kaolinite, illite, pyrite, and quartz. The valuable minerals had been successfully removed from the Coarse circuit.

By thickening the as-received 10-wt% tailings stream to 37 wt% solids, it is possible to remove 73% of the water volume using A-3338 polymer flocculant at a dosage of 300 ppm. The centrate from this thickener trial contained 0.25 wt% total solids, which would be acceptable for direct return to the extraction process. The quality of the centrate could be controlled by varying the flocculant dosage, with lower dosages resulting in higher solids in the centrate.

Since the settling performance in a thickener for this material was relatively good, an opportunity to recycle hot water was identified. Thickener underflow performance was evaluated in a thin lift deposition test and was found to have the potential to meet the 5-kPa requirement of AER's Directive 74 (superseded by Directive 85). Hot water recycle could also be achieved through centrifugation, allowing for the resulting cake to be deposited without the need for fluid containment. If hot water recycle is not required, rim ditching could be a viable option to meet AER directives as rapid dewatering was also demonstrated using this technology. CVW CleanTech has advanced tailings thickener designs in subsequent engineering activities conducted by Canadian Natural with testwork support by SNF Mining and Thurber Engineering to confirm the consolidation potential.

The possibility of acid mine drainage from this tailings stream must be considered due to the accumulation of pyrite in the froth streams. For the solvent recovery unit tailings sample tested, the pyrite concentration (about 14% by weight of mineral) is sufficiently high for acidification under certain depositional conditions. CVW CleanTech has designed a pyrite removal circuit in the Mineral Separation Plant and advanced tailings thickener designs in subsequent engineering activities.

3.6.6. Paraffinic Froth Treatment Tailings Processing

As a clean technology developer, CVW CleanTech has processes to extract resource values from tailings solvent recovery unit ("**TSRU**") bottoms while providing material environmental benefits. These tailings are generated in PFT processes (current commercial operations include Muskeg River, Kearl and Fort Hills mines) and utilize paraffin in their froth treatment process resulting in a partially de-asphalted bitumen ("**DAB**") product and TSRU tailings with some asphaltenes enrichment. This is different from the naphtha-based froth treatment operations of Suncor's base plant operations, Syncrude's Mildred Lake and Canadian Natural's Horizon in which asphaltenes are retained with the bitumen.

The successes with the naphtha-based froth treatment ("**NFT**") tailings remediation have been translated to the remediation of PFT tailings through a process validation development stage; a 500 g/min pilot plant was executed at SGS facilities in Lakefield, Ontario (bitumen recovery) and CanmetENERGY at Devon, Alberta (solvent recovery) utilizing naphtha as the extractant. This continuous pilot plant to produce bitumen from the fines fraction of these tailings was executed over a four week period in March 2011 (Moran & Doiron, 2011). Processing involved solvent extraction operated in a two-stage counter-current decantation circuit. Process raffinates were treated with steam to recover residual solvent and produce clean tailings utilizing the Company's solvent recovery demonstration unit. The solvent extraction circuit demonstrated excellent bitumen recovery values, averaged at 87.4 ± 7.1% (**Figure 25**). Solvent recovery from raffinates was more than 90%. This pilot was augmented with dewatering exercises and processing tests on the recovered bitumen, which was enriched with asphaltenes. Further, produced HMC was processed to extract marketable zircon. With these encouraging results, stakeholders (SDTC, select oil sands operators with PFT plants) agreed to facilitate another pilot campaign to confirm and validate the flowsheet.

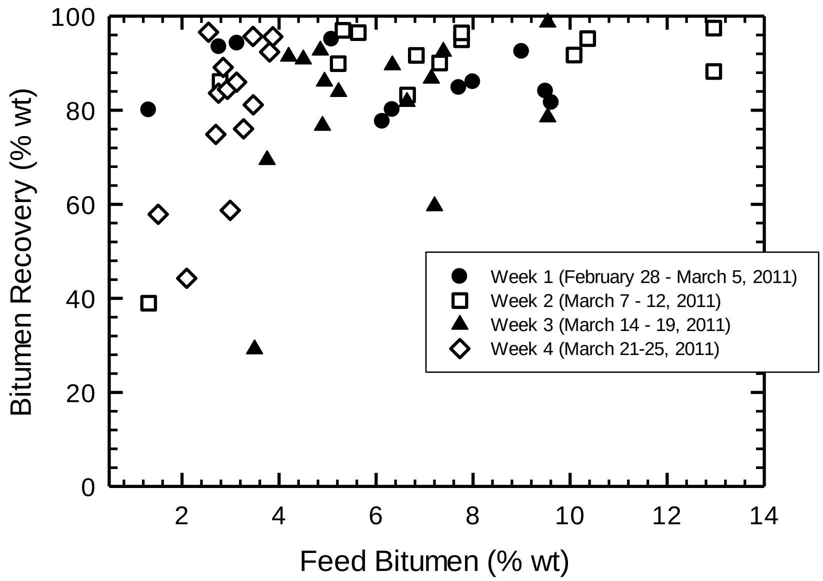

Figure 25. Bitumen Recovery performance of CVW^{TM} technology processing PFT tailings at the SGS Lakefield pilot.

The pilot plant equipment tested at Lakefield was installed with the Company's pilot assets at CanmetENERGY for a ~8700 kg campaign scheduled from November 2012 to May 2013 (Moran, 2013). In this testing, whole PFT tailings were processed through a two stage solvent extraction unit utilizing naphtha as the extractant at the industry stakeholders' request. Approximately 6000kg of PFT tailings were processed with rates pushed to 1kg/min. During the steady operational period, the key program metric was met with the bulk of the 47 material balances closing within acceptable cumulative errors. The extraction circuit recovered 81% of the contained bitumen into a diluted bitumen product (**Figure 26**) and over 98% of solvent within the raffinate stream was recovered in a steam distillation operation (**Figure 27**). Resultant process tailings contained about 1% bitumen and less than 0.08% solvent. The CVW^{TM} process is tuneable to recover asphaltenes and maltenes or selective to maltenes.

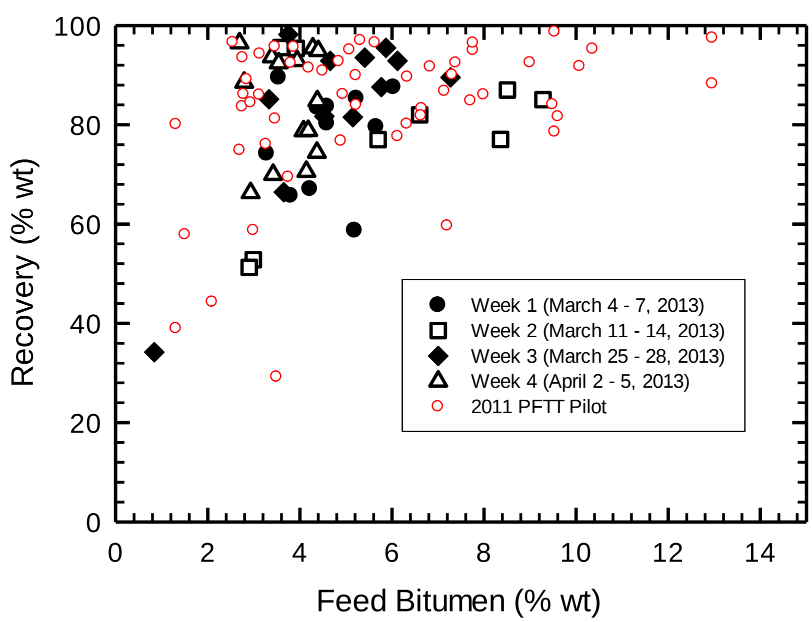

Figure 26. Bitumen Recovery performance of CVW^{TM} technology processing PFT tailings at the Integrated Demonstration Pilot.

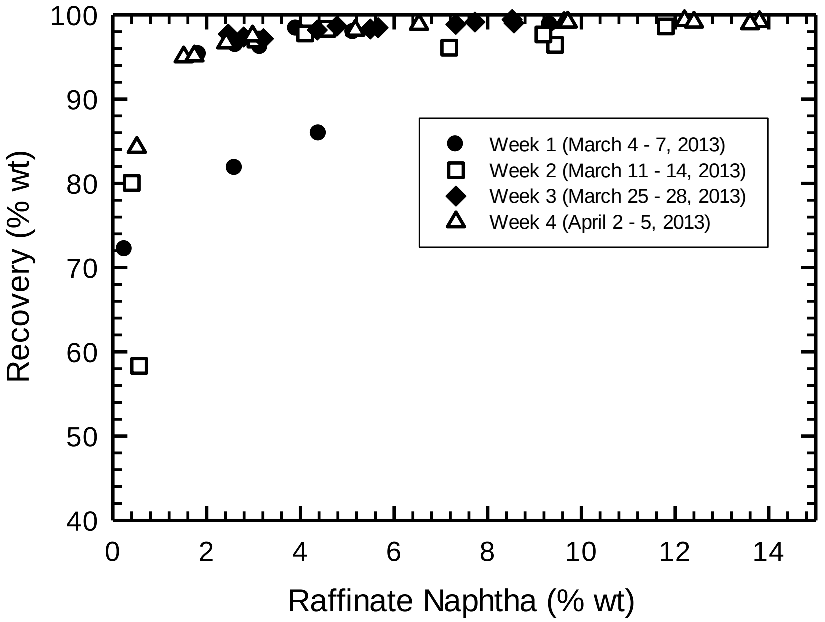

Figure 27. Solvent Recovery performance of CVW^{TM} technology processing PFT tailings at the Integrated Demonstration Pilot.

The resulting tailings, owing to low bitumen content, were subjected to a range of tailings management testing at the CanmetENERGY facility (Mikula, Dickson, & Elias, 2011), with positive results regarding consolidation potential meeting AER directives and hot water recovery. CVW CleanTech retained experts at CanmetENERGY and Gas Technology Institute to assess the upgrading (Khuble, Rahimi, Alem, Sadowski, & Garez, 2012) and gasification (Gas Technology Institute, 2012) potentials of the asphaltenes-enriched bitumen recovered by the Company's process. Results indicated that significant liquid yield was achievable in coking operations and sufficient heating values in produced syngas, suggesting the economic potential of the asphaltenes-enriched tailings bitumen.

3.6.7. Industry and Public Views

In the COSIA 2012 Tailings Technology Roadmap, the CVW™ process was identified as a 'prioritized' technology, ranking number 16 out of over 600 reviewed technologies (Sobkowicz, 2012). CVW™ was the only technology identified that provides value-added resource recoveries while achieving important environmental improvements. In a 2015 study for Natural Resources Canada, the Council of Canadian Academies identified the environmental issues related to FTT pond deposition and recommended separate pre-pond remediation of these tailings, citing CVW CleanTech's (then named Titanium Corporation) CVW™ as the lone identified solution (Council of Canadian Academies, 2015). The Council of Canadian Academies emphasized CVW™ potential for the recovery of existing VHM from waste, in addition to significant environmental benefits. Full lifecycle carbon accounting by independent experts, including Lenef Consulting (Flint, 2011), Stantec Engineering (Stantec Consulting, 2018) and The Delphi Group (The Delphi Group, 2021) has verified the significant net GHG emissions reductions potential of commercial implementation of the CVW™ technology.

3.7. Optimization, Modelling & Validation

3.7.1. Mineral Products Optimization

Following the Integrated Demonstration Pilot minerals processing test work, which defined processes to recover premium grade zircon and HiTi titanium-bearing mineral products from the FTT stream, testing was conducted to produce zircon and titanium mineral concentrates (Kruger, 2020); (Kruger, 2020); (IHC Robbins, 2021) in efforts to optimize commercial CVW™ projects. All processing schemes involve a front-end wet processing mill and subsequent dry mill operations. All wet processing was conducted with gravity spirals, flotation cells and wet magnets. All dry processing was achieved with high tension rolls and rare earth and/or induced magnets. Further details are provide in the **Appendix**.

Processing of the HMC produced in the Integrated Demonstration Pilot's Concentrator Plant was achieved on a stage-by-stage basis and resulted in the development of mineral separation processes. During the Integrated Demonstration Pilot, the primary dry circuit produced a non-conductor concentrate that was subsequently processed to primarily make premium grade zircon and some zircon concentrate. In these studies, a non-magnetic concentrate was processed in a dedicated dry circuit to make a zircon concentrate product. In these works, pyrite was removed from the HMC prior to dry circuit processing to further unencumber zircon recovery.

The minerals optimization testing resulted in a significantly higher recovery of zircon, at 87.4%, into a concentrate that was comprised of over 75% zircon. A key difference in the optimization testing was the removal of the wet zircon circuit and modifications to the dry processing of the non-magnetic concentrate from the Concentrate Upgrade Plant. Relaxation of specifications to concentrate grade allowed for material improvements in recovery in the dry circuitry.

In the minerals optimization program, titanium minerals were produced from a magnetic stream produced in the wet mill with some scavenging through the downstream zircon concentrate production circuitry. The optimization flow sheet resulted in significantly greater titanium minerals recoveries, when compared to the testing conducted during the Integrated Demonstration Pilot, at 85.4%, 64.7% and 52.1% for ilmenite, leucoxene and rutile respectively, into a chloride ilmenite product that is characterized by 72% TiO_2. The mineralogy of the chloride ilmenite product consists of approximately 51% ilmenite, 37.5% leucoxene and 6.5% rutile.

3.7.2. Geotechnical Testing

From 2018 to 2019, CVW CleanTech worked with an oil sands operator, engaging industry experts Thurber Engineering and SNF Mining to advance the CVW CleanTech tailings thickening process and understand integration potential with a host site tailings management plan (COSIA, 2020). Model tailings, generated with varying amounts of residual bitumen, were thickened in a laboratory scale dynamic thickener. Rheological testing indicated that the thickened tailings shear stress increased significantly when the thickened material was characterized by 50% weight of solids, setting a practical design criterion for a commercial thickener and pumping system.

The thickened tailings samples were subjected to geotechnical tests to provide the information required to develop a deposition and reclamation strategy for CVW™ tailings. This testing included hindered sedimentation testing and large strain consolidation testing to evaluate the compressibility and hydraulic conductivity as a function of effective stress. In general, all thickened tailings samples were classified as clay of intermediate plasticity (as per the Unified Soil Classification System) or as fine tailings (F-2, sand-to-fines ratio < 1 as per the Unified Oil Sands Tailings Classification System). This information will be used in modeling and predicting the consolidation behaviour of CVW™ thickened tailings when deposited in a tailings disposal facility.

3.7.3. Modelling

Industry experts were engaged by CVW CleanTech to advance scaling design for the TDUs via computational fluid dynamics modelling during significant engineering activities related to project development. Two independent studies conducted by Canada Research and Development Corporation (Vakil, 2021) and Hatch Engineering (Hatch Engineering, 2021) showed agreement with the hydraulic performance and operability of full-scale TDU vessels and provided validation for the Company's vessel designs and select critical components.

04

Project Description

4. Project Description

4.1. Basis for Project Description

The CVW™ commercial project, as further described in the subsequent sections of this document, illustrates how the CVW CleanTech technologies could be implemented and operated at a typical oil sands mining site. A significant number of assumptions were required to allow for the illustration to be completed.

The project is assumed to be designed and installed within an existing oil sands mining site, within close proximity of the operator's froth treatment plant. Where the full project, later described as the EcoMax (as defined below) option, is installed, there are three separate, but interconnected facilities involved. These include the Concentrator Plant, the Mineral Separation Plant and a thickener. The CP facility houses the bitumen recovery, HMC and solvent recovery circuits.

The facilities for this project are assumed to be sized to allow for processing the full FTT from the host plant, assuming operations that process 250,000 bbl/d of SCO. The host site is assumed to operate at a utilization rate of 95%. These bases are founded on commercial oil sands facilities' performance metrics (**Table 11**) with the Concentrator Plant and Mineral Separation Plant both operating at a relative utilization rate of 90%.

Table 11. Summary of oil sands mining operations in the Athabasca region with upgraders producing SCO or DAB. Production values were obtained from the AER (ST-39) five-year average from 2018 to 2022. Note that the utilization average does not include Fort Hills, which is a relatively new facility.

MINING OPERATION	PRODUCT	PRODUCTION (KBBL/D)	CAPACITY (KBBL/D)	UTILIZATION
Suncor Base Mine	SCO	311,140	300,000	104%
Syncrude Mildred Lake	SCO	295,164	350,000	84%
CNUL MRM/JPM	DAB	298,631	320,000	98%
Canadian Natural Horizon	SCO	224,752	252,000	89%
Imperial Oil Kearl	DAB	243,443	240,000	101%
Suncor Fort Hills	DAB	135,057	194,000	70%
Average		**251,365**		**95%**

The entirety of FTT from the host site have been assumed to be intercepted from the tailings line before its deposition into the ponds and diverted to the CP. The feed tailings stream is presumed to occur at approximately 2,500 tonnes per stream hour and would be forecast to be comprised of 2% bitumen, 0.2% naphtha and 18.8% solids (Foulds, 2013) which is consistent with the material sampled by CVW CleanTech during its sampling program. The solids fraction composition has been set by the oil sands operator to be 50% fine particulates (-44 microns). THM content in the solids fraction, modelled upon CVW CleanTech's sampling efforts, has been presumed to be 16.3%. This valuable mineral fraction is further comprised of 10.6% zircon, 3.6% rutile, 16.8% leucoxene and 17.2% ilmenite based on tailings sampling data (**Table 5**). After the mineral separation component has been completed, the CVW™ processed tailings are assumed to be released to the host site for integration in their existing tailings management operations.

4.2. Project Infrastructure

CVW CleanTech has done extensive engineering studies and costed preliminary engineering designs to accommodate the CVW™ facilities on the existing premises of an oil sands operator's site. This is beneficial for CVW CleanTech due to the close proximity of the feedstock source (FTT from the froth treatment plant) and close proximity to tailings disposal pipeline systems and areas. A model rendering of the CVW™ Concentrator Plant developed in the Company's joint engineering studies with an oil sands operator is shown in **Figure 28**. The host froth treatment plant is in the background.

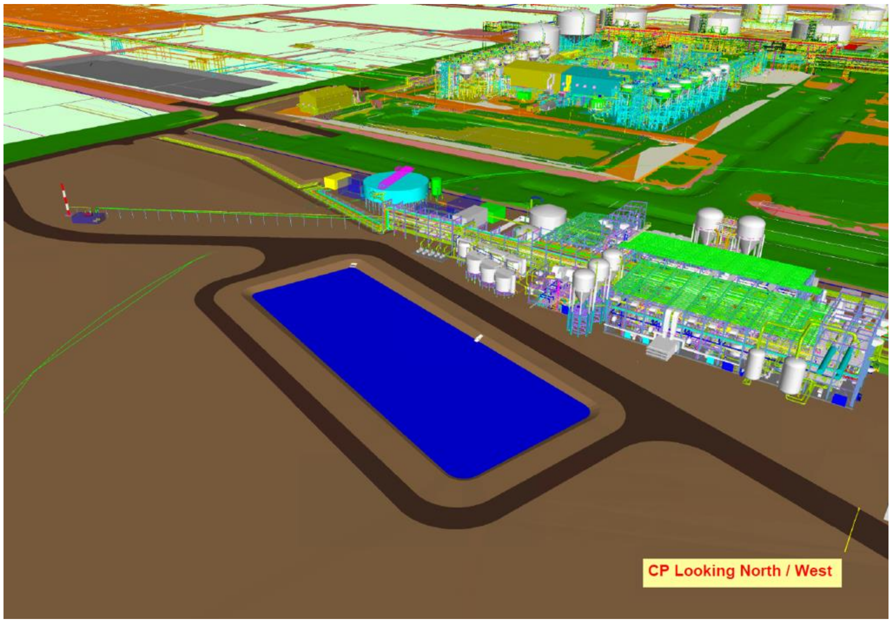

Figure 28. Model rendering of the CVW™ Concentrator Plant integrated at an oil sands mining operation. The CP is in the foreground and the host froth treatment plant is shown in the background (Emissions Reduction Alberta, 2019).

The co-location of the CVW™ facilities on an oil sands operator site also presents other opportunities to tie into other existing infrastructure such as roads, utilities and services such as personnel transport and emergency services.

4.2.1. Access

The CVW™ facility will make use of the existing main road access to an oil sands operator's site but will also include the development of secondary access and maintenance ways within and around the immediate CVW™ facilities. Critical access for firefighting vehicles has also been included in the facility layout and designs.

4.2.2. Tie-ins

The CVW™ facility is fully integrated with the oil sands operator's facilities and covers the various process, utilities and other service tie-ins.

4.2.2.1. Process Tie-Ins

The CVW™ facility involves engineered tie-ins into existing FTT lines, allowing for two 18" diameter pipelines. Engineered tie-in of CVW™ tailings return line into existing FTT line, or alternatively use a dedicated thickener underflow pipeline with booster pumphouse system. These include two engineered tie-ins for recovered warm water return, two engineered diluted bitumen return lines into the oil sands operator's froth treatment plant, and one 8" diluent supply pipeline. CVW™ produced naphtha is recycled within the process battery limits in certain configurations.

4.2.2.2. Firewater

Firewater will be provided via tie-ins to the existing underground fire ring main system at two specific points to allow for redundancy and typical oil sands operator safety standards.

4.2.2.3. Electrical

The CVW™ facility allows for three tie-in taps to existing 72kV transmission lines. Two transmission lines will provide redundant power to the CP plant. The 72kV taps terminate at a common, open utility station to transform to the 4160 VAC power distribution system.

4.2.2.4. Control and Telecom

The control system for the Concentrator Plant will be tied into the existing oil sands operator's distributed control system using similar philosophies, equipment and protocols (i.e. including a redundant fibre optic cable connection to the control room).

A VoIP (voice over internet protocol) telephone system with a high-speed internet connection will be tied in to existing service provider's infrastructure, also co-located at the oil sands operator's site.

4.2.2.5. Site Drainage

The proposed surface water management system for the CVW™ site will consist of a series of swales, ditches and culverts, which will direct any stormwater run-off discharge into the existing storm water system.

4.2.3. Flare

The CVW™ CP includes a flare (including a knock-out drum, flare stack and all ancillaries). Regulatory approval will be needed for this design from the AER. There is also the opportunity to connect to the oil sands operator's existing froth treatment flare header.

4.2.4. Vapor Recovery

The vapor recovery unit ("**VRU**") captures hydrocarbon vapours, including solvent components, from process units in the CP. The VRU building is approximately 217 m^2. The building houses many pieces of equipment including two VRU pumps, two VRU compressors and a closed hydrocarbon drain tank inside a concrete sump as secondary containment. The VRU has a feedstock capacity of up to ~600 kg/h.

4.2.5. Boiler

The boiler generates process steam for use in the CP and MSP. The boiler and associated water treatment/polishing plants are housed in three buildings with a total footprint of 1,100 m^2. The boiler system is sized based on 75 tph units, including one as redundancy.

4.2.6. Process Safety

Technical Safety for the project covers the fire protection and the process safety of the facility. The following is the list of deliverables that have been completed during the Company's FEED validation exercises: technical safety philosophy, design safety concept, fire hazard assessment (including modelling, safety in design, active and passive fire protection), vapor cloud explosion, fire hazard zone layout, fireproofing layout, fire fighting layout, assembly, muster and egress layout and fire water demand calculations to comply with the host site Emergency Response Plan.

The following safety areas will be addressed in a detailed design exercise: update FEED hazard and operability study report, egress route study and fire and gas layouts, design criteria and piping and instrument diagram ("**P&ID**").

4.3. Regulatory and Permitting

4.3.1. Host Oil Sand Operator's Site

CVW CleanTech has advanced critical regulatory issues in relation to a CVW™ project on a host oil sands mining site. A CVW™ installation is not identified as an activity on the regulations designating physical activities, schedule 1 ("**RDPA-1**"). Preliminary regulatory work carried out as part of the FEED project indicated the project would require an amendment to the existing permits held by the host operator for their oil sands mining site. The operator will be required to submit certain amendment applications to allow a CVW™ project to be constructed and operated on its site, including the *Oil Sands Conservation Act*, its approval under the *Environmental Protection and Enhancement Act* ("**EPEA**"), and its license under the *Water Act*. The host site operator could grant CVW CleanTech a sub-lease under its existing mineral surface lease under the *Public Lands Act* to allow CVW™ to be constructed on a parcel of developed land on the existing processing plant site. The project is not likely to trigger an environmental assessment ("**EA**") process under the federal *Canadian Environmental Assessment Act* (2012), as it is not a designated activity under RDPA-1, nor is it located on federal lands.

A provincial EA is required for those activities on provincial land designated as mandatory in the Environmental Assessment (Mandatory and Exempted Activities) Regulation, pursuant to the EPEA. A provincial EA may also be required for those activities that are not explicitly exempted under the same legislation. The EA director, Alberta Environment and Parks ("**AEP**") will ultimately decide whether or not an activity that is not mandatory and not explicitly exempted would require an EA under provincial legislation. Upon extensive consultation, the feedback received by the Company indicates that an EA may not be required.

In addition to the project review process under the AER, there are requirements to engage with Indigenous groups affected by the project. CVW CleanTech previously requested a pre-consultation assessment from the Alberta Aboriginal Consultation Office ("**ACO**"). The ACO determined no consultation would be required as there would be no trigger for the Crown's duty to consult. To meet its regulatory requirements under the AER's Directive 023, for its due diligence, and to establish positive community relations, CVW CleanTech initiated engagement efforts with several Indigenous communities during the FEED phase, including Fort McKay First Nation, Fort McKay Métis Community, Fort McMurray First Nation #468, Mikisew Creek First Nation, Athabasca Chipewyan First Nation, Fort McMurray Métis Local 1935 and Fort Chipewyan Métis Local 125. To date, CVW CleanTech has initiated contact with all the communities. CVW CleanTech participated in an operator's annual stakeholder forum on tailings management in Fort McMurray in 2018 to which representatives from the aforementioned Indigenous communities had been invited. The Indigenous communities with whom CVW CleanTech has had more detailed conversations over the FEED project phase have indicated a positive interest in the CVW™ project, including an interest in taking an equity position or making a financial investment in the project or in CVW CleanTech. Based on this initial interest and positive feedback along with the environmental benefits of our process, the Company considers the risk of delay to the regulatory review or legal challenge to the regulatory approval based on Indigenous concerns to be low and manageable.

4.3.2. Off-site MSP – Impact on Permitting

In a phased approach to the development of a CVW™ project, the Company has contemplated developing one or more centralized Mineral Separation Plants that would process clean mineral concentrate feedstocks from multiple Concentrator Plants located at host sites. These facilities will be remote facilities located in a zoned industrial area in the Wood Buffalo region. These facilities will require separate permits, as follows: air emissions from fluid bed mineral dryer stacks, building permits and an EA of the site.

4.4. Environmental Benefits

CVW™ technology is designed to remediate oil sands FTT, recovering lost hydrocarbons, bitumen and solvent, preventing their release into tailings ponds and the atmosphere. Once deposited into a mature tailings pond, naphtha serves as a substrate for biogenic methanogenesis which results in fugitive methane release from ponds to the atmosphere (**Figure 29**), which is a serious issue reported in numerous science-based studies (Small, 2015). Further, bitumen resides as 'mats' that rest on the surface of the fluid fine tailings ("**FFT**") layer in ponds and, due to biogenic gas production within the FTT, are a source for hydrocarbon contamination at the surface of the pond (Syncrude Canada, 2022). As oil sands operations mature, methane emissions from ponds increase, with individual ponds reporting annual methane emission levels as high as one megatonne of carbon dioxide equivalents (Kong, et al., 2019).

Implementation of the CVW™ technology at an oil sands mining site will significantly reduce future methane emissions from tailings ponds and will reduce harmful critical air contaminant ("**CAC**") emissions of VOCs and secondary organic aerosols ("**SOA**"). Further, CVW™ will produce high quality bitumen and naphtha (from FTT) that will offset incremental mining, extraction and upgrading emissions to produce equivalent baseline bitumen and naphtha volumes, resulting in additional GHG emissions reductions on a functional equivalency basis, as well as provide opportunities for heat integration with related benefits to both land-use and water-use profiles. The recovery of critical minerals and production of valuable mineral concentrates from these tailings also provides important GHG emissions offsets.

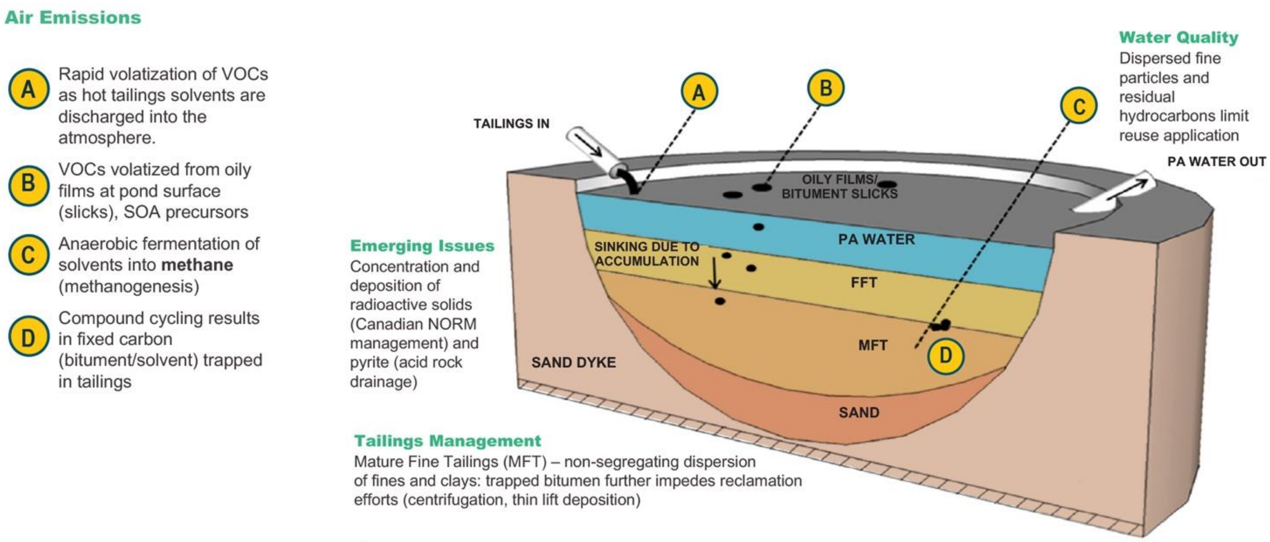

Figure 29. Sources of air emissions from oil sands tailings ponds, including anaerobic fermentation of solvents. Adapted from (Small, 2015).

4.4.1. GHG Emissions Abatement

Annual emissions profiles for an illustrative CVW™ technologies installation at a 250,000 bbl/d SCO oil sands mining operation are collated in **Table 12**. The project GHG emissions profile is presented as a range between lower and upper bounds based on available data and calculations to present the potential benefit accruing to CVW™ technology. Independent consultants examined the environmental benefits of a CVW™ project in conjunction with CVW CleanTech's SDTC grant for project engineering. They confirmed meaningful GHG emissions benefits accruing to the project (The Delphi Group, 2021). These values have been scaled to the current project rate. The Delphi Group estimate of CVW™ process emissions includes a scope 2 component for natural gas production and a relatively high value for electrical emissions intensity from 2019. This intensity is forecast to be significantly lower as renewable sources are brought on line. The Delphi Group analysis did not contemplate heat integration potential. Based on site-wide GHG emissions reported by operators, CVW™ implementation would lead to site-wide emissions reductions of approximately 5-10%.

Table 12. Net GHG emissions benefits accruing to CVW™ implemented at a typical oil sands mining operation producing 250,000 bbl/d SCO. An emissions range is indicated between lower and upper bounds. Independent analysis utilizing emissions factors from the Delphi Group is also shown. Average host site emissions obtained from government data (Alberta Environment and Parks, 2021).

	LOWER BOUND (t CO_2e/a)	UPPER BOUND (t CO_2e/a)	DELPHI GROUP (2021) (t CO_2e/a)
Tailings Pond Methanogenesis	308,548	644,016	605,293
Bitumen Recovery	56,691	69,331	76,615
Naphtha Recovery	53,965	88,144	76,430
Heat Integration	102,834	168,942	—
Minerals Production	54,387	78,100	61,258
CVW™ Process	(196,428)	(196,428)	(268,120)
Net Benefit	379,997	852,104	551,477
% site-wide emissions	5.4	12.1	7.8

4.4.1.1. Fugitive Tailings Pond Emissions

CVW™ addresses fugitive methane emissions in oil sands mining by preventing hydrocarbons from entering tailings ponds and the atmosphere, reducing methane/GHG emissions resulting from their microbial metabolization into methane. The GHG emissions reductions achieved with CVW CleanTech's process are a result of the reduced volume of hydrocarbons discharged to an oil sands tailings pond and the atmosphere. Extensive scientific studies (Siddique, 2007) have established that once released into a tailings impoundment, light hydrocarbons, such as naphtha, are metabolized by microbes and release GHGs, primarily methane. Reported tailings pond emissions intensities are collated in **Table 13**. These emissions intensities are based on field studies, technical reports and a carbon accounting model developed by AEP. Fugitive tailings methane emissions from tailings ponds are reflected as emissions intensity in carbon dioxide equivalents per barrel of bitumen produced by the oil sands operator. Note the following factors: energy content of bitumen = 6400 MJ/bbl and methane global warming potential = 28 (Alberta Environment and Protected Areas, 2023).

The table below indicates that measured fugitive tailings emissions from mature oil sands operations are at ~5-10 kg CO_2e/bbl of bitumen, representing up to ~10% of site-wide GHG emissions of ~81.5 kg CO_2e/bbl bitumen (Sleep, 2021) at 88% SCO yield.

Table 13. Summary of Published Tailings Pond Fugitive Emissions Intensities from Oil Sands Mining Sites.

SOURCE	DATE	EMISSIONS INTENSITY (kg CO_2e/bbl bitumen)	NOTES
Syncrude[a]	1998	9.9	CAPP report; field study
Syncrude/University of Alberta[b]	2000	5.7	Tailings pond field study
Nodel Consulting[b]	2005	8.3	Emissions study for Total E&P
University of Calgary[d]	2010	13.6	Land-use emissions estimate
Jacobs Consultancy[e]	2013	8.9	Methane emissions intensity reduction - CVW™ technology study
Environment and Parks[f]	2014	5.5 – 7.4	Diluent methanogenesis model
Environment and Parksg[h, i]	2015-2021	2 – 11	Field reporting by oil sands producers 2011-2021

Sources: a – (Canadian Association of Petroleum Producers, 1999); b- (Holowenko, MacKinnon, & Fedorak, 2000); c – (Nodel Consulting Ltd, 2005) ; d – (Yeh, et al., 2010); e – (Keesom, O'Brien, & Blieszner, 2013); f – (Burkus, 2014); g – (Alberta, 2017); h- (Kong, et al., 2019); i – (Sleep, 2021)

In addition to operator reporting, these fugitive tailings methane pond emissions intensities are estimated using the AEP model that calculates methane evolution from tailings ponds using hydrotreated naphtha as the fermentable substrate (Burkus, 2014). The operator reporting is based on measurements made in accordance with Alberta guidelines (Alberta, 2019). These two methodologies represent low and high bounds for tailings pond fugitive methane emissions described in this analysis. The AEP model correlates well with existing scientific data, independent studies and tailings fugitive emissions reported to AEP by the oil sands operators for mature tailings ponds. Emissions intensity values are ultimately governed by naphtha physical characteristics, the NLI of the oil sands operation and the nature of the microbial communities within the ponds. Note that the industry has been testing new methods to measure fugitive emissions and reported values have trended downwards in recent years. The upper bound for the 'business-as-usual' baseline used in this analysis is 7.4 kg CO_2e/bbl bitumen which is within the range reported in **Table 13** and corresponds to a NLI of 3.8, which is also within observed industry performance for naphtha losses. The lower bound for the baseline used in this analysis is obtained from industry self reporting, at ~ 3.5 kg CO_2e/bbl bitumen for mature oil sands operations. The accruing tailings methanogenic emissions benefit is the difference between these baseline ('business as usual') intensities and those realized by the implementation of CVW™ technologies. CVW™ will recover over 90% of the naphtha from FTT, preventing its release into tailings ponds and avoiding subsequent fugitive methanogenic releases. CVW™ will reduce emissions intensity to about 0.3 kg CO_2e/bbl bitumen, characterized by a resultant NLI of less than 0.5 bbl/kbbl bitumen.

The AEP model informs that at design production of 250,000 bbl/d SCO, the upper bound baseline case (emissions intensity 7.4 kg CO_2e/bbl) will emit approximately 644,000 tonnes CO_2e annually, comprised of ~90% methane (CO_2e) and the balance being carbon dioxide. Using the tailings emissions data reported to the government by operators, the lower bound base case emits approximately 309,000 tonnes CO_2e annually. At 90% utilization relative to froth treatment operations and using the above ranges, CVW™ will reduce tailings pond GHG emissions to ~31,000 to 64,000 tonnes of CO_2e per year. The net effect on methanogenic release is the difference between the baselines and emissions with CVW™ implementation, or about 580,000 tonnes of CO_2e annually at the upper baseline and 275,000 tonnes of CO_2e annually at the lower baseline.

4.4.1.2. Incremental Hydrocarbon Production Equivalents

Implementation of CVW™ at an oil sands site results in significant emissions intensity reductions and realized net emissions reductions related to equivalent bitumen production. The benefit can be estimated from public data on oil sands bitumen production emissions and factored against the relative uplift in net bitumen produced with CVW™ integration.

The first step in this assessment is to evaluate the current emissions ascribed to the mining and extraction of bitumen at Athabasca oil sands mining sites. Data reported to the Alberta government by operators indicates the three-year emissions intensity of naphtha-based oil sands mining operations is 73.8 kg/bbl bitumen, or about 85 kg/bbl SCO (Alberta Environment and Parks, 2021). The mining and extraction functions at these sites account for 41% of the total emissions (Sleep, 2021), indicating an emissions intensity of 30.3 kg CO_2e/bbl bitumen. This represents a lower bound for this analysis and is somewhat consistent with independent estimates made for Canadian Natural's Horizon mine at ~33 kg CO_2e/bbl bitumen (Sleep, 2021) based on similar operator reported data.

The upper bound for our analysis is based on the Argonne National Laboratory's GREET1 model ("**GREET1**") for oil sands bitumen production (Argonne National Laboratory, 2022). This model takes into account emissions related to direct energy consumption related to bitumen extraction and separation, flaring, non-combustion emissions and also includes net credits due to co-generation. Transportation emissions are not incorporated into this analysis. The emissions products include carbon dioxide, methane and nitrous oxide. The global warming potential emissions factors applied to methane and nitrous oxide are 25 times and 298 times, respectively, that of carbon dioxide. The GREET1 estimate for mining and extraction emissions is 37 kg CO_2e/bbl bitumen.

The project contemplated in this study is presumed to be sized at host site production rate of 250,000 barrels of SCO per calendar day. This corresponds to annual bitumen of just over 106 MMbbl of bitumen produced annually by the mining and extraction function. CVW CleanTech estimates that as a result of implementing the CVW™ technologies at a host site, there would be a recovery of 85% of the bitumen lost to tailings, which represents about 1.5% of host production. This incremental bitumen production offsets the equivalent emissions incurred during its mining and extraction. At the lower bound emissions intensity, this is estimated at 56,700 tonnes of CO_2e annually. At the upper bound defined by GREET1 emissions intensity, the functionally equivalent emissions offset is 69,300 tonnes of CO_2e per year.

CVW™ technology not only recovers incremental bitumen, but it also realizes incremental naphtha values that can offset equivalent production and associated GHG emissions at an oil sands mining site in both the upgrading and extraction functions. Two approaches have been adopted to estimate the functional equivalent benefits from the CVW™ project regarding incremental naphtha production representing upper and lower bounds. The first is based on public data provided by the operators to the Alberta government and the second is developed using the GREET1 model.

The CVW™ project illustrated herein would recover an incremental amount of high-quality naphtha relative to host naphtha production as a component of SCO. As a functional equivalent offset, this incremental production serves as the baseline for related GHG emissions reduction benefits. This incremental production represents an increase in naphtha production of about 1% against annual the baseline naphtha production of the host operator mine. A host site is assumed to emit emissions at an intensity of 73.8 kg/bbl bitumen as per self reporting to the government (Alberta Environment and Parks, 2021). Of this, 43.5 kg CO_2e/bbl bitumen is ascribed to the upgrading of bitumen to SCO based on operator reporting. This is notably lower than recently reported independent values of 54.6 kg CO_2e/bbl bitumen (Sleep, 2021). Further, the portion of upgrading emissions that can be attributed to naphtha production is about 40%, including front end distillations, coking, naphtha hydrotreating and related hydrogen production (Nimina, 2015), indicating the intensity of producing naphtha is about 17.4

kg CO_2e/bbl bitumen. As such, the net emissions intensity in producing naphtha from oil sands mining based on government reports is 47.7 kg CO_2e/bbl bitumen, which includes the 30.3 kg CO_2e/bbl bitumen emitted during mining and extraction. The second methodology to estimate functional equivalent GHG benefits accruing to CVW™ is naphtha recovery data within the GREET1 fuel cycle model. This model informs that bitumen extraction emission intensity is 37 kg CO_2e/bbl bitumen. The emissions intensity for bitumen upgrading to a naphtha product is comprised of primary upgrading emissions, related to crude and vacuum distillation as well as coking/hydrocracking operations, and naphtha hydrotreating. These components can be derived from GREET1 modeling with primary upgrading emissions intensity at 12.1 kg CO_2e/bbl bitumen and naphtha hydrotreating emissions intensity of 8.7 kg CO_2e/bbl bitumen. The net intensity of producing naphtha from bitumen at an oil sands mining operation is then 57.8 kg CO_2e/bbl bitumen.

Considering these methodologies and observations, the illustrations prepared for the CVW™ project assume that there would be 328,000 barrels of naphtha recovered per year from the host FTT, representing the equivalent volume of bitumen of 1.5 MMbbl annually. At the low bound, the functionally equivalent emissions offset afforded by the CVW™ naphtha recovery function is 54,000 tonnes of CO_2e annually. At the upper bound, CVW™ implementation will realize GHG emissions offsets of 88,100 tonnes of CO_2e per year due to incremental naphtha production.

4.4.1.3. Heat Integration

The elimination of hydrocarbons from oil sands FTT by CVW™ technologies also allows the efficient recovery of hot water. A key aspect of efficient tailings management performance is the efficacy of polymer flocculants in binding with solids surfaces to achieve sedimentation. The flocculant activity in binding with solids is improved by reducing residual hydrocarbon content, thereby significantly reducing the flocculant usage required to achieve effective dewatering. CVW CleanTech's process allows for up to a three-fold reduction in polymer loading, resulting in the release of clean hot water from the treated tailings stream. The hot water is suitable for re-use and a portion is planned to be recycled back into the CVW CleanTech process, while the excess water could be used within the host site's extraction plant. This would reduce the natural gas consumption required to heat an equivalent amount of ambient temperature process water from tailings ponds and achieve further GHG reductions.

A lower bound for this project benefit is estimated by considering indirect heat transfer through an exchange system. Estimates are based on recovery of 70°C water from the thickener and exchanging energy with recycle process water or utility water at ambient environmental temperature and heating it to approximately 40°C. An upper bound for this heat integration opportunity considers direct mixing of the recovered hot water with recycle process water volumes to reduce the temperature of the cooled thickener overflow to about 30°C. At design thickener water production levels of 1,900 tonnes per hour and 90% utilization relative to host plant operations, the lower bound estimates about 102,600 tonnes of CO_2e offsets annually. At the upper bound, CVW™ would offset up to 170,000 tonnes per year of CO_2e. These estimates utilize natural gas combustion and production emission factors of 49.7 kg CO_2e/GJ and 8.8 kg CO_2e/GJ (Environment and Climate Change Canada, 2018).

4.4.1.4. Existing Minerals Recovered From Tailings

The CVW™ process, as illustrated herein for a typical oilsands mining operation, would allow valuable titanium and zircon concentrates to be filtered from oil sands FTT. This has the functional equivalent of producing concentrates from conventional beach sands deposits that involve mining and/or dredging operations that are avoided by reprocessing tailings. From this perspective, the CVW™ processing offers GHG emissions benefits owing to the elimination of mining functions from the equivalent basis.

An upper bound of this estimate can be derived from a life-cycle analysis commissioned by the Zircon Industry Association ("**ZIA**") to determine the GHG emissions intensity of VHM production (Morfino, 2017) with a value of 0.32 kg CO_2e per kilogram of product. This emissions intensity includes emissions of carbon dioxide, nitrous oxide and methane and covers the mining function that contemplates emissions from the mine face to the production of final sand. A lower bound for minerals functional equivalent emissions offsets afforded by CVW™ implementation can be ascertained from ecoinvent data on zircon and titanium mineral production (The Delphi Group, 2021). The production intensities for these minerals are 0.337 kg CO_2e/kg zircon, 0.108 kg CO_2e/kg ilmenite and 0.699 kg CO_2e/kg rutile. The intensity for leucoxene was estimated as the average of those for rutile and ilmenite. For both estimates, the ZIA study provides a break-out of the mining phase, which includes operations from the mine face to the end of the wet concentration stage at 70% of total operations. This is approximately equivalent to the CVW™ processing, although the CVW™ process does include some additional dry milling to produce concentrates.

At design CVW™ Mineral Separation Plant processing rates, the project would be forecast to produce about 161,700 tonnes of titanium-bearing minerals annually (rutile, leucoxene, ilmenite) into a concentrate and 54,300 tonnes annually of zircon into a zircon concentrate. The lower and upper bounds of functionally equivalent annual emissions benefits accruing to CVW™ minerals production from FTT are 38,900 tonnes of CO_2e and 50,800 of tonnes CO_2e for purposes of the illustrations herein.

4.4.1.5. CVW™ Process Emissions

CVW™ utilizes low pressure steam for heating and process applications in the CP and MSP. Electricity is required to operate machinery including pumps, compressors and mixers as well as minerals processing equipment in the MSP. Natural gas is utilized to operate driers in the MSP and provide heating in the facility buildings.

The CVW™ technologies, implemented as illustrations herein, would produce approximately 196,400 tonnes of GHG emissions from electricity (21.4 MWh) and natural gas consumption (320 GJ/h). The electrical emissions intensity in 2030 is forecast to be 192 kg CO_2e/MWh (Innovation, Science and Economic Development Canada, 2021). The electrical GHG emissions intensity reflects anticipated emissions efficiency gains in the Alberta grid, anticipated by the Federal government, by 2030. The emissions factor used in these illustrations for natural gas consumption is 49.7 kg CO_2e/GJ, and for natural gas production is 8.9 kg CO_2e/GJ (Environment and Climate Change Canada, 2018). Note that a hydrocarbon only phase of a project would emit 94,200 tonnes of CO_2e annually at design rates as developed for these illustrations.

4.4.2. Critical Air Contaminants

Implementation of CVW™ technologies, as presumed for the purposes of illustrative modelling, at a host oil sands mine will reduce future methane emissions from tailings ponds while also reducing harmful CAC emissions of VOCs and SOAs.

4.4.2.1. Volatile Organic Compounds

The direct recovery of process naphtha from hot FTT prior to deposition in tailings impoundments prevents emissions of VOC which are harmful to human and wildlife health. In mining oil sands operations, FTT are deposited into tailings ponds, where between 5% and 30% of the naphtha mass can volatilize into the atmosphere as VOCs, depending on temperature and other atmospheric conditions. This flashed naphtha can account for a significant proportion, in excess of 50%, of reported oil sands mining VOC emissions (Environment Canada, 2021). At 10% atmospheric volatilization, consistent with calculations utilizing the AEP model for methanogenesis, the reduction of VOC emissions resulting from the implementation of CVW™ technologies has been estimated to be approximately 5,000 tonnes per year.

4.4.2.2. Secondary Organic Aerosols

SOAs related to FTT have been identified by Environment Canada as an emerging public health concern (Liggio, 2016). SOAs are related to their light hydrocarbon precursors, including naphtha components from FTT, and are emitted at a rate ranging from 16,000-30,000 tonnes annually in the oil sands region. SOA precursors are captured by CVW™, thereby preventing their emission to the environment.

4.4.3. Water-Use Benefits

Naphtha contamination in FTT limits the re-use of water from FTT operations owing to the potential to generate naphtha vapor that can contribute to safety hazards. CVW™ recovers naphtha from FTT to well below detection limits, allowing its use as recycle process water. Further, the water produced by the CVW™ TDUs is distilled and can offset raw (river) water requirements in its boiler service. The MSP requires both raw water, for deck filter flushing, and cooled process water, which is to be supplied by the host site under the current embodiment of the CVW CleanTech project that serves as the reference facility for this estimate.

The baselines for water-use benefits accruing to the CVW™ installation are the functional equivalencies of importing raw water only for the CVW™ boiler service and the filter deck service required in the MSP. Further water-use benefits are realized within

CVW™ including offsetting imported recycle water for cyclone underflow fluidization, but these benefits are not considered explicitly here due to inconsistency with functional equivalent analysis. The mineable oil sands baseline is that reported by the AER at 2.44 m^3/m^3 SCO (Alberta Energy Regulator, 2022) and that for the minerals production function is 20 tonnes per tonne of product (Morfino, 2017). The net water-use intensity for the base case is 3.071 m^3/tonne product.

The raw water requirement of the CVW™ project process is 770,000 m^3 per year, including efficiencies such as the reuse of distilled water from the TDU overheads as boiler feed water, which offsets about 470,000 m^3/a of raw water imports. While the water-use intensity on a hydrocarbon basis for the project slightly increases, that for the mineral production functions is dramatically reduced for a net project water use intensity of 1.607 m^3/tonne of product, which includes recovered hydrocarbons and critical minerals. The net water use benefit on this basis is about 2.8 million m^3 of raw water per year.

The CVW™ thickening operation, enhanced by TDU's ability to remove hydrocarbons from tailings, is assumed for purposes of these illustrative models to produce an additional 14.9 million m^3 (1,890 m^3/s-h; *stream hours*) of recycle process water annually that could be exported from CVW™ to the host site for re-use (and participate in waste heat recovery as described above).

4.4.4. Land-Use Benefits

Naphtha contamination in FTT reduces the effectiveness of tailings management operations (such as thickening) and may preclude its deposition for AER Directive 85 reclamation purposes. CVW CleanTech's TDU technology recovers naphtha from FTT which improves thickening performance and allows for the potential for AER Directive 85 compliance as 'ready- to-reclaim' tailings. The land-use benefit that results from CVW™ implementation at a presumed oil sands mining host site is related to reduced disturbance to the mine face and subsequent tailings deposition in ponds resulting from a functionally equivalent production of bitumen and naphtha.

The CVW™ illustrations for a typical oil sands mining host site contemplate the use of a thickener to reduce FTT volumes by ~65% (2500 tph FTT in the baseline case to 940 tph thickened CVW™ tailings in the project case). It is important to emphasize that this performance could not be achieved without the removal of hydrocarbons from the FTT. The cleaned and thickened tailings have the potential to be deposited into dedicated disposal areas that are consistent with reclamation initiatives under the AER's Directive 85.

Estimating the mining land-use benefit afforded by CVW™ implementation begins with an acknowledgment of an accepted mining site land-use intensity of 0.4 m^2/m^3 SCO (Jordaan, 2009). At SCO production corresponding to the CVW™ design basis with net production at 14.5 Mm^3 SCO per year, the functionally equivalent land use is estimated at 599 Ha/a. When considering the project case for mining land-use, accounting for the incremental production of bitumen and naphtha via CVW™ processing of 2.9 MMbbl per year in SCO barrel equivalents, the effective CVW™ land-use intensity associated with the mining functional equivalency is 580 Ha/a and the net mining land-use benefit is then 19 Ha/a.

4.4.5. Other Environmental Benefits

CVW™ can have a positive impact on other environmental issues related to oil sands solids including acid rock drainage and deposition of naturally occurring radioactive material ("**NORM**"). Pyrite is concentrated in FTT and the heavy minerals fraction contains about 8% pyrite by weight. Pyrite causes 'acid mine drainage' and leaching of heavy metals into the water table in tailings ponds and subsequent tailings reclamation deposits. The AER's Directive 85 contains sub-objectives requiring tailings management practices to address this acidification (Alberta Energy Regulator, 2016). CVW™ technology will efficiently segregate the contained pyrite into a highly concentrated, small volume stream, thereby enabling cost effective management of pyrite in environmentally benign sub-aerial depositions consistent with AER Directive 85 objectives, which recommends control of acidification characteristics.

Radioactive critical minerals are also concentrated in FTT. FTT pond depositions and planned AER Directive 85 terrestrial and aquatic reclamation landscapes can exceed Canadian NORM guidelines and impact workplace exposure safety limits (Health Canada, 2014). CVW™ effectively manages these radioactive materials continuously, eliminating radioactive build-up and exposure. Approximately 320 GBq/a will be removed from an oil sands site in CVW™ zircon and HiTi products, representing a reduction of ~10% of baseline radioactivity levels, thereby reducing the radioactivity of tailings deposition and reclamation. Note that the CVW™ mineral products can be characterized by uranium and thorium levels below 600 ppm and unrestricted release level classification under Canadian NORMs guidelines. The remaining radioactive material will be managed in tailings deposits at lower activity levels compared to the current baseline.

4.5. Commodity Recoveries and Cost Savings

A summary of the hydrocarbon and mineral recoveries expected by the installation of the CVW™ technology at a host oil sands operation producing 250,000 bbl/d is presented below. In addition to the commodity recoveries, the CVW™ technology will also provide the host operator with certain operational benefits which have also been presented in the summary.

Table 14. Summary of Commodity Recoveries and Operational Benefits

	UNIT	METRIC
Recoveries		
Bitumen Recovery	(%)	85%
Naphtha Recovery	(%)	91%
Minerals Recovery	(%)	73%
Volumes		
Bitumen	(MMbbl/a)	1.9
Naphtha	(bbl/a)	328,000
Chloride Ilmenite	(tpa)	170,200
Zircon Concentrate	(tpa)	72,600
Operational Benefits		
Tailings Management	(tpa)	1.5
Heat Integration	(GJ/a)	1.9

4.5.1. Hydrocarbon Recoveries

The CVW™ process is forecast to recover 85% of the bitumen contained in FTT. At the project design rates, the oil sands operator could potentially recover 1.87 MMbbl annually of bitumen. This bitumen is suitable for upgrading, at a yield of 85.4% (Alberta Energy Regulator, 2022), to SCO by the host operator.

Naphtha would be recovered from FTT by the CVW™ process, largely through the TDU. At project design rates of 91% recovery, CVW™ could recover 328,000 bbl/a of naphtha. This naphtha can be re-used within CVW™ and host processes, or contribute to host SCO production.

4.5.2. Mineral Recoveries

The CVW™ process is designed to clean and recover valuable critical minerals from FTT, which would be expected to include critical minerals such as zircon and titanium-bearing concentrates. The zircon concentrate is forecast to contain 75% zircon sands. The titanium-bearing concentrate, referenced as 'chloride ilmenite', is expected to be comprised of rutile (7%), leucoxene (40%) and ilmenite (53%). The valuable titanium minerals comprise 95% of the chloride ilmenite product. At CVW™ design production rates, 72,600 tpa of zircon concentrate and 170,200 tpa of chloride ilmenite could be produced. The net critical mineral recovery is 73%. Both concentrate products can be exported to global markets. Both concentrate values are on free on board basis to the Company's planned Lynton railhead facility.

4.5.3. Tailings Management

CVW™ processing of FTT would be designed to enable tailings management cost savings realized by the operator through the integration of CVW™ thickened tailings with the host tailings management plan. CVW™ would be forecast to effectively capture 98% of the fine solids contained in the FTT (Mikula, Dewatering Treatment Options for Titanium Corporation Naphtha Froth Treatment Tailings, 2010) and render them into a thickened slurry that appears compliant with the AER's Directive 85 mandates. This processing offsets equivalent processing, and associated costs, that would be borne by the operator. Note that this analysis only considers the physical dewatering of the clean tailings and not the cleaning functions that occur upstream in the CVW™ process. The hydrocarbon removal is an essential step to enabling compliance with the regulated management of tailings. This is expected to reduce the tailings material handled by the host site operator by 1.5 tonnes annually.

4.5.4. Heat Integration

In the CVW™ FTT remediation processes, almost the entire slurry volume reports to a water recovery operation that also creates thickened tailings for integration with the host tailings management plan. Significant volumes of hydrocarbons are removed from the tailings by CVW™ processing, such that the hydrocarbon concentration would be reduced by over 85%. It is the low residual hydrocarbon levels that contribute to accelerated dewatering of the process tailings, allowing for the release of hot water and realizing the heat recovery potential, first identified during the Company's piloting at the Integrated Demonstration Pilot (Mikula, Dewatering Treatment Options for Titanium Corporation Naphtha Froth Treatment Tailings, 2010). Subsequent testing has confirmed the enhanced rates and amounts of water release (Niederhauser, 2018); (Li, 2018); (Booshehrian, 2019).

In the Company's suite of technologies to remediate FTT, the cleaned process tailings from the flotation circuits, the Fines' TSRU and the Mineral Separation Plant report to a thickener. The thickener operation would be expected to recover about 1890 tpsh (stream hour) of water, representing about 80% of the water in the thickener feed slurry. Clean water, characterized by low suspended solids content of 0.2%, would be produced at a temperature of about 76°C. This quality improved water could be used in other processes such as gland seal service that currently may source fresh river water, thereby reducing river water draw. Since the naphtha concentration is negligible, this hot water source would not need to be reclassified and, in the proposed application, can be directly blended into the recycled process water for the primary extraction operation.

Additional incremental GHG emissions reduction would be realized by offsetting natural gas consumption required to heat cold tailings pond water. In estimating the potential benefits of heat integration, the waste heat recovery from CVW™ thickener overflow, considers a baseline of ambient recycle process water available at an oil sands extraction operation at 20°C. In a conservative practical case, it is assumed that the waste heat is recovered in an indirect heat exchanger operating at 91% efficiency (Stantec Consulting, 2019) and that the CVW™ recovered water will be cooled to ~50°C, allowing an equivalent amount of ambient recycle process water to be heated to 44°C. The energy required to heat an equivalent volume of water from ambient to operating temperatures amounts to an annual load of 1,929,065 GJ assuming indirect heat transfer through a heat exchanger. Alternatively, in the case of direct heat transfer via blending with recycle process water, the annual load would be 3,200,000 GJ. This power would be supplied by natural gas consumption (no efficiency assumptions for a conservative estimate).

4.5.5. GHG Abatement

A CVW™ project is forecast to generate GHG emissions benefits as described in section **4.4**. The emissions reductions realized by CVW™ would be eligible for participation in the provincial carbon levy system, the Alberta Technology Innovation and Emissions Reduction Regulation ("**TIER**").

4.6. Execution Schedule

The CVW™ project has adopted a cost and quality driven strategy including precise cost estimating, integration issues, project risks and planning appropriate mitigation measures including: organizing the project into logical smaller components to improve resource efficiency, scheduling and cost control; modularization of process components for efficient and cost effective fabrication off-site to minimize site construction costs and time; fixed cost quotations for critical portions of engineering, procurement and construction; and contingency planning in anticipation of labor, material, logistical, weather and other disruptions. CVW CleanTech and its potential oil sands partners have experienced project management resources which can identify expert engineering firms and consultants with relevant experience. CVW CleanTech has developed strong positive working relationships with potential stakeholders, including potential host operators.

A qualified engineering, procurement and construction management firm will take a lead role in engineering, procurement and construction management activities. In addition, expert consultants will be retained for detailed engineering and design of the CP and MSP, materials handling and load-out facilities, geotechnical studies and other support activities.

A Construction Execution Plan ("**CEP**") previously developed during CVW CleanTech's FEED and validation engineering studies would be presumed to serve as a base for a CVW™ installation. The CEP outlines how, by whom and in what sequence construction will be executed. The CEP is the primary controlling document for defining construction execution strategies, procedures and work processes. A construction management team will ensure a safe, productive and cost driven execution for the project. The CEP will include:

- establishment of a construction management organization with a primary construction contractor that has experience and a proven track record on related oil sands construction projects and/or other similar project environments;
- implementation of robust safety, quality and regulatory compliance programs that are consistent with corporate standards of the stakeholders and proven industry practices;
- a contracting strategy that is built on multiple construction packages and contracts that are aligned with contractor capabilities and risk tolerance;
- construction proceeding on a modularization basis to minimize on-site person hours and optimize overall cost efficiencies during the execution of the work; and
- effective interface management of the CVW™ plant areas and tie-ins with the host plant facilities including the creation of a management and oversight committee comprised of executives of both partners.

4.6.1. Engineering and Permitting

Engineering efforts to deploy the CVW™ technologies in the manner envisioned in these illustrations include the need to complete a site specific FEED review and updating capital costs to current levels at the date of project commencement. This would be followed by a detailed engineering exercise to bring the project definition to AACE Class 2. Required permitting for the illustrative CVW™ project as described herein would precede significant detailed engineering effort and overlap with the FEED work. It is anticipated that these efforts would require approximately six to nine months for FEED and approximately 15 months for detailed engineering.

4.6.2. Procurement and Construction

Construction would be implemented in three phases, beginning with early works that involve site preparation, underground installations and placement of pilings for facility and process structures. The construction effort is presumed to occur over a 36 month period.

4.6.3. Commissioning

The illustrative project as described herein forecasts a six-month window following finishing works to commission the facilities and reach minimum conditions of satisfaction in advance to turn-over to operation teams. The project schedule is presented in **Figure 30**.

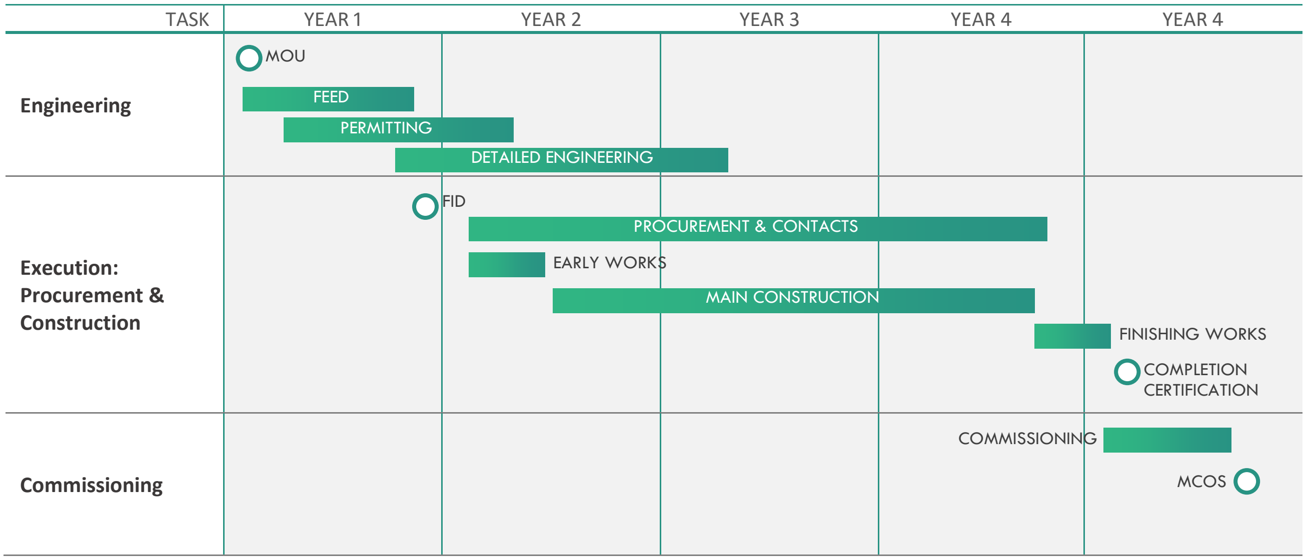

Figure 30. Project Gantt chart indicating engineering, construction and commissioning phases of a CVW^{TM} project.

05

Development Approach and Financial Summary

5. Development Approach and Financial Summary

The below represents indicative preliminary estimates based on the ownership and operation of the project on a stand-alone basis. The following information is not intended to imply any economic returns or interest therein to CVW CleanTech and is subject to certain assumptions, including those listed below as well as those set forth under "*Financial Information*" and "*Forward-Looking Information*".

5.1. Development Options

CVW CleanTech has analyzed a variety of development scenarios that allow for the development and deployment of the CVW™ technology including an option that is focused exclusively on hydrocarbon recoveries ("**EcoBase**"), a phased approach to development ("**EcoFlex**") as well as an approach which deploys the entire technology suite at once ("**EcoMax**").

These development options allow CVW CleanTech and the Company's potential oil sands partner to balance up front capital costs and development risk with long-term economic and environmental benefits. All three development options provide significant reductions in GHG emissions from tailings ponds, while simultaneously removing existing hydrocarbons from the operator's tailing streams. Each of these options have differing capital expenditure profiles.

In all scenarios, the time from the commencement of detailed engineering works and start of construction through to commissioning and start-up have been estimated at five years, consistent with the FEED study previously completed by CVW CleanTech and an oil sands operator. These forecasts have been prepared at the project level, and do not include any assumptions associated with financing of the project. All facilities are assumed to be integrated with a host oil sands operation and upgrader that produce 250,000 barrels of bitumen per day.

CVW CleanTech has provided annual values of key metrics based on estimates as disclosed herein.

5.1.1. EcoBase

The EcoBase option allows the operator to enhance hydrocarbon recovery on site, reduce the volume of bitumen and solvent lost to tailings and abate GHG emissions through the development of a standalone CP. This option does not include the capital components required to benefit from mineral processing and marketing. As a result of removing the Coarse circuit within the CP and removal of the mineral separation facilities, the capital costs are significantly lower. The major components of this option include the bitumen recovery circuit, along with the solvent recovery, tailings management and water recovery modules. Developing this scenario with a site layout mirroring the full deployment of the CVW™ technologies will maintain future optionality for the recovery of minerals through the addition of a Coarse circuit in the concentrator.

5.1.2. EcoFlex

The EcoFlex option will provide the operator with the benefits of the EcoBase, but will allow for future development of minerals processing. This option allows for greater flexibility in the timing of the second phase of development and can allow for greater choice in managing capital, construction and financing needs including utilizing cash flow from the CP. If the operator does not wish to move into the second phase of development, to allow for mineral processing and marketability, hydrocarbon recovery and GHG abatement benefits will continue to accrue to the operation. The EcoFlex option includes the initial development of a CP with a bitumen recovery circuit, with a secondary phase of development for the heavy minerals production circuit and MSP.

5.1.3. EcoMax

The EcoMax option is designed to deploy the full complement of CVW™ technologies. This option is designed from day one to maximize hydrocarbons otherwise lost to tailings streams, reduce GHG emissions from tailings ponds and provide new revenue from the MSP. Component facilities of a full project include a CP, comprised of a bitumen recovery circuit and heavy minerals production circuit each with an associated TDU, and a MSP.

5.2. Key Assumptions

5.2.1. Commodity Prices, Exchange Rates and Long-Term Bond Rates

CVW CleanTech has made certain assumptions around macroeconomic factors including exchange rates, long term bond rates and commodity prices that are not under its control (**Table 15**). CVW CleanTech's assumptions for hydrocarbon prices are based on conservative estimates below current prevailing market prices and the 3-year average. CVW CleanTech has also made certain assumptions around differentials for certain key products including realized SCO and naphtha prices based on a conservative view of 3-year average pricing.

Table 15. Summary of Macroeconomic Assumptions

METRIC	ASSUMPTION	SPOT AS OF 06-30-2023	3-YEAR AVERAGE
CAD/USD Exchange Rate	**$1 USD = $1.30 CAD**	$1 USD = $1.324 CAD*	1.2978*
Canada Long Term Bond Rate	**3.20%**	3.20%**	2.14%**
WTI Price (US$/bbl)	**$60.00**	$70.64^	$71.50***
SCO Premium / (Discount) to WTI	**$2.00**	$2.18***	$0.93***

* (Bank of Canada, 2023)
** (Bank of Canada, 2023)
*** (Natural Resources Canada, 2023) SCO spot as of May 31, 2023
^ (The Globe and Mail, 2023)

For minerals product pricing, CVW CleanTech has based its estimates on forecasts from TZ Minerals International Pty Ltd ("**TZMI**") which is a world leading consulting firm in the mineral sands industry and are conservative relative to spot prices (**Table 16**).

Table 16. Summary of mineral pricing assumptions. Zircon concentrate discount is determined by contained valuable mineral content. Leucoxene is valued at a 50% discount relative to rutile.

METRIC	ASSUMPTION	SPOT AS OF 04-30-2023*	TZMI LONG TERM
Zircon (US$/t)	**$1,710.0**	$2,224.0	$1,710.0
Zircon Concentrate Discount (%)	**25%**	n.a.	25%
Rutile (US$/t)	**$1,301.0**	$1,405	$1,301.0
Leucoxene (US$/t)	**$650.5**	$702.0	$650.5
Chloride Ilmenite (US$/t)	**$314.0**	$372.0	$314.0

* (TZMI Pty, 2023)

5.2.2. Carbon Tax Pricing

The carbon tax price assumption applied in the forecasts is based on TIER which implements Alberta's industrial carbon pricing and emissions trading system (**Table 17**). TIER regulated facilities include those that emitted 100,000 tonnes or more of carbon dioxide equivalent in any year after 2016 which would include all oil sands mining operations. The TIER system meets federal requirements under the *Greenhouse Gas Pollution Pricing Act* and is tailored to Alberta's industries and priorities.

Table 17. TIER Carbon Pricing Schedule

	2023	2024	2025	2026	2027	2028	2029	2030
C$/T	$65.0	$80.0	$95.0	$110.0	$125.0	$140.0	$155.0	$170.0

5.2.3. Provincial Royalty Rates and Income Tax Rates

A CVW™ project would be subject to corporate income tax and provincial royalty expenses (**Table 18**). The provincial royalties applicable to the project would include oil sands royalties on hydrocarbon production and metallic mineral royalty on the production of zircon and titanium. The oil sands royalty rate is applied to the projected bitumen volume recovered from waste streams at the bitumen royalty price as determined by Alberta's Bitumen Valuation Methodology (Alberta, Bitumen Valuation Methodology Regulation, 2021). The metallic minerals royalty rate applies to mine mouth revenue which deducts transportation costs or net revenue which also deducts operating expenses for the HMC production area and the MSP.

Net income for tax purposes would be reduced to taxable income by estimating an amount for capital cost allowance relating to project capital expenditures. Corporate income taxes would be based on the forecast taxable income for the project, by applying a corresponding tax rate of 23% which would include the current federal and provincial corporate tax rate.

It should be noted that the royalty rates used in the annual estimates are accurate at the current time, but the actual royalty rates that will be levied on a CVW™ project will be influenced by many factors including, but not limited to, the timing of capital expenditures, changes in taxation policies at a federal or provincial level, and any investment incentives that may be available to implement a CVW™ technology. Fiscal benefits under pre-payout royalty rates are available and are expected to be utilized by a CVW™ project.

Table 18. Alberta Bitumen and Mineral Royalty Rates

METRIC	ASSUMPTION
Bitumen Royalty Rates (Pre-Payout)	
Royalty rate if WTI greater than $120	9.00%
Royalty rate if WTI less than $120 and greater than $55	Based on linear calculation between 1.00% and 9.00%
Royalty rate if WTI less than $55	1.00%
Bitumen Royalty Rates (Post-Payout)	
Royalty rate if WTI greater than $120	40.00%
Royalty rate if WTI less than $120 and greater than $55	Based on a linear calculation between 25.00% and 40.00%
Royalty rate if WTI less than $55	25.00%
Metallic Minerals Royalty Rate (Pre-Payout)	1% of mine mouth revenue
Metallic Minerals Royalty Rate (Post-Payout)	Greater of: 1% of mine mouth revenue or 12% of net revenue

5.2.4. Methodology Used

The annual analysis for a CVW™ project was undertaken utilizing a cash flow model incorporating the revenues, operating expenses and royalties applicable to the CVW™ project. The estimates were developed using Microsoft Excel spreadsheet software.

5.2.5. Basis and Quality of Estimates

The data used to compile commodity recoveries, environmental cost savings, operating cost estimates and capital cost estimates for this illustrative, possible commercial application of the CVW™ technology at an oil sands operation, have been derived from several sources. Sources include but are not limited to observed data from the Integrated Demonstration Pilot, previously completed FEED and engineering validation studies and information reported to the Province of Alberta.

During one project conducted with a partner, a FEED optimization study was compiled. In its basis of estimate, it was determined that the project estimate met expectations for an AACE Class 3 estimate in support of project authorization (typically an engineering design specification level of design maturity). AACE classification is based on attaining a minimum level of project maturity as expressed by specific project and technical deliverables. Key required thresholds for attaining an AACE Class 3 estimate are that the estimate is supported by completed plot plans, major equipment lists, and project-specific P&ID that have completed hazard and operability analysis ("**HAZOP**").

The MSP was engineered to an AACE Class 3 level by FWS Energy Ltd. (facilities) and IHC Robbins (mining). The estimate was consolidated by the operator's engineering team and then validated by a third-party expert consultant (Conquest Consulting Group, 2021).

These estimates have been scaled from observed data and other previous engineering studies to arrive at the estimated commodity recoveries, environmental cost savings, operating cost estimates and capital cost estimates for a host oil sands site that processes 250,000 bbl/d.

5.3. Financial Estimates

5.3.1. Revenue

The major components that would drive attributable revenue for the project owner are comprised of streams for hydrocarbon recovery from tailings waste, GHG emissions abatement, minerals recovery from waste streams and operational cost savings for the oil sands operator, resulting from reduced tailings rehandling and heat integration benefits. Commodity revenues are summarized in **Figure 31**.

Forecast hydrocarbon recovery revenue has been based upon estimated metered volumes of recovered bitumen and naphtha solvents, at forecast commodity prices. These volumes are expected to be consistent across all the various development options.

The bitumen is expected to be upgraded on the host oil sand operation for a cost of US$9/bbl (Oil Sands Magazine, 2023) with a SCO yield of 85.4% (Alberta Energy Regulator, 2023). Based on the assumed WTI price of US$60/bbl and a SCO premium of US$2.00, the realized SCO price assumed is C$68.90/bbl.

Minerals recovered from the processed FTT have been projected to include zircon concentrate and ilmenite chloride. The volume of minerals recovered at the forecast commodity price forms the basis for this revenue stream. Please see the discussion in section **4.5.2** regarding mineral testing and sampling conducted.

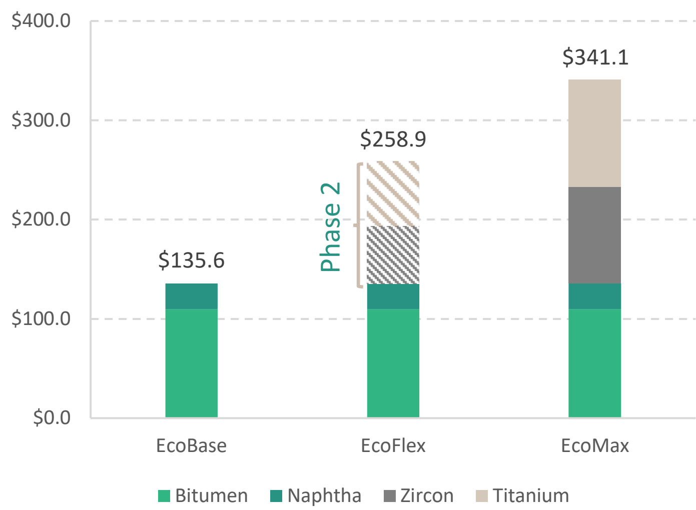

Figure 31. CVW™ Average First 10 Years Commodity Revenues by Development Approach.

Revenue attributable to the project is also based upon the forecasted volume of GHG emissions that could be expected to be abated. The model assumes that between ~380,000 and ~428,000 tonnes of CO_2e will be abated annually (**Table 19**). For each tonne of CO_2e abated, revenue is projected to be earned at Alberta TIER rates currently in place.

Table 19. Summary of GHG emissions abatement benefit for a CVW™ installation at a 250,000 bbl/d host oil sands site.

METRIC	ECOBASE	ECOFLEX	ECOMAX
TP methanogenesis	308,548	308,548	308,548
Bitumen Production Functional Equivalent	56,691	56,691	56,691
Naphtha Production Functional Equivalent	53,965	53,965	53,965
CVW™ Operational Emissions	(94,216)	(94,216)	(94,216)
Heat Integration	102,834	102,834	102,834
Total	**427,822**	**427,822**	**427,822**
Minerals Production Functional Equivalent	—	54,387*	54,387
CVW™ - Coarse Circuit Operational Emissions	—	(79,159)*	(79,159)
CVW™ - MSP Operational Emissions	—	(23,053)*	(23,053)
Net benefit	**427,822**	**379,997**	**379,997**

* Emissions are applicable for Phase 2 only following development of the Coarse Circuit and MSP.

Minerals CO_2e impact follows development of the MSP in Phase 2 of development As a result of implementing CVW™ tailings management and water recovery techniques, an oil sands operator could reduce existing operating costs on site. Tailings rehandling would be minimized by 1.5Mt per year by implementing the CVW™ technologies, leading to reduced operating costs at the host site. In addition, the oil sands operator would reduce their heat requirements by 1.9 million GJ per annum as a result of heat integration from processed water. Please see the discussion in sections **4.5.3 and 4.5.4** regarding tailings rehandling and heat integration from processed water. Revenue from the tailings improvement fee has been estimated at a rate of $21.57 per tonne and water heat integration has been estimated assuming natural gas prices of $3.59 / GJ (Alberta Energy Regulator, 2023). These operational cost savings are expected to be consistent across all the various development options.

The forecasted annual revenue for a CVW™ project ranges from $248 million for the EcoBase option to $446 million with the EcoMax option with the higher revenue attributable to the additional revenue from the sale of minerals (**Figure 32**).

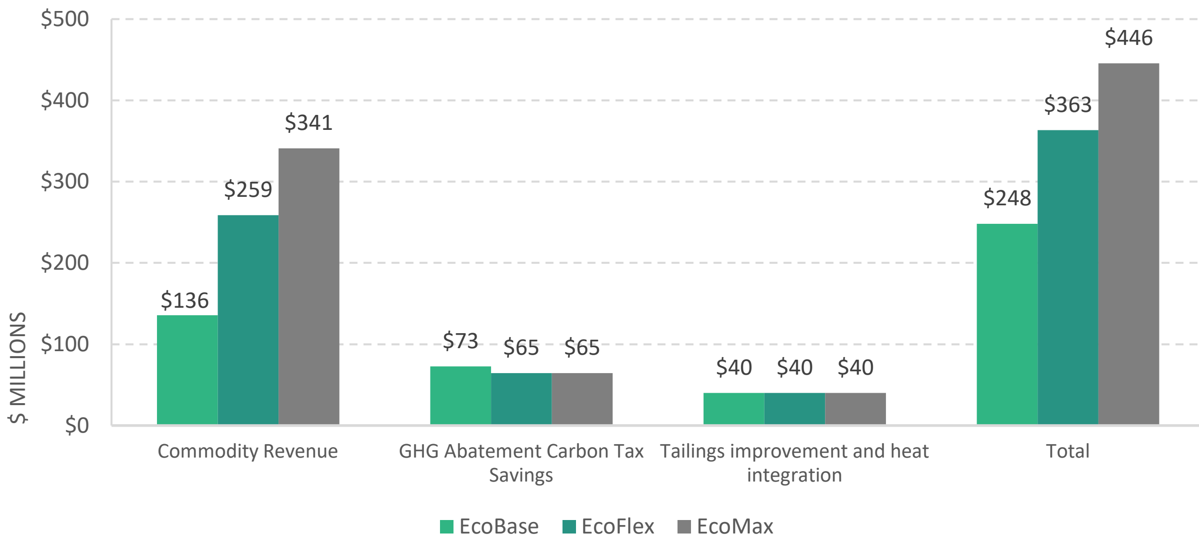

Figure 32. CVW™ Project First 10 Year Average Revenue Breakdown by Development Approach

5.3.2. Direct Operating Costs

Direct operating costs could be expected to be comprised of amounts for utilities, consumables, transportation, and personnel costs (**Table 20**). Direct operating costs differ depending upon the development option chosen from the three choices more fully described in the 'Development Options' section.

Table 20. Operating cost estimates for a CVW™ installation at a 250,000 bbl/d host oil sands site. Operating costs for Phase 2 within the EcoFlex option are inclusive of Phase 1.

	ECOBASE	ECOFLEX		ECOMAX
Utilities	9.3	Phase 1 Phase 2	9.3 24.4	24.4
Consumables incl. Minerals Laboratory	2.3	Phase 1 Phase 2	2.3 6.5	6.5
Personnel	5.1	Phase 1 Phase 2	5.1 16.3	16.3
Transportation	–	Phase 1 Phase 2	– 28.0	28.0
Total Operating Cost Estimate (Excluding Transportation)	**17.0**	**Phase 1** **Phase 2**	**17.0** **47.5**	**47.5**

5.3.2.1. Utilities

Utilities would include the cost of electricity and natural gas. Electricity supplied through the host site power system and the electrical grid is required to operate machinery including pumps, compressors, mixers, instrumentation and building functions. Estimates for electricity costs are based on $0.085/kWh (Alberta Electric System Operator, 2021) with the full CP load at 16.5 MWh and the MSP load at 5.0 kWh. The hydrocarbon only phase of the CP would be forecast to have a load of 6.6 MWh and that for the HMC production area is 9.9 MWh.

Natural gas supplied through the host site infrastructure would be required to generate steam for heating and process applications, including the TDU in the CP and dryers and high-tension roll humidification in the MSP. Estimates for natural gas costs are based on $3.59 GJ (Alberta Energy Regulator, 2023) with the full CP load estimated at 321 GJ/h and the MSP load estimated at 22 GJ/h. The hydrocarbon only phase of the CP (EcoBase) consumes 182 GJ/a and natural gas consumption for the HMC production area is 139 GJ/h.

5.3.2.2. Consumables

Consumables would include charges for chemical aids, thickening agents and flocculants. The annual consumables cost for the full CP is estimated at $3.4m and the MSP at $0.5m. The hydrocarbon only phase of the CP has an annual estimated consumables cost of $1.3m with the HMC production area estimated at $2.1m. Testing and analyses are conducted on key process streams during operations for quality assurance and process control support. These include a suite of established oil sands testing to determine the material composition of process streams as well as bitumen and naphtha products. Utilizing the existing bitumen production lab at the host oil sands operation is expected to cost $2.5m for the full CP which is split out into $1.0m for the hydrocarbon only phase and an additional $1.5m for the HMC production area.

The MSP is outfitted with an automated laboratory to conduct minerals quality testing, including chemical analysis via XRF which is forecasted to cost $0.1m per annum which would only apply to the EcoFlex and EcoMax development options to support the MSP.

5.3.2.3. Personnel

Personnel costs would include charges for labour, benefits, accommodation and travel for all project staff. The full CP will require 46 personnel and the MSP will require 62 staff. In a phased approach, with the hydrocarbon only component of the CP installed first, 33 staff will be required for operations. In a subsequent expansion to minerals production, an additional 13 staff will be required to support operations of the HMC production circuit. The cost per employee is assumed at an average cost of $153,079 per person based on the FEED study completed by CVW CleanTech and an oil sands operator.

5.3.2.4. Transportation

Transportation expenses would be incurred to move produced mineral concentrates from the host site to market. This would include trucking the material to the Lynton Transload facility and then transportation via rail. Transportation costs have been estimated to deliver the zircon and HiTi to ports on Canada's west coast at $115.28/tonne for export to global markets.

5.3.3. Capital Costs

Capital costs differ depending upon the development option chosen from the three choices more fully described in the 'Development Options' section **5.1**. These estimates include an inflation factor of 11.3% based on Canadian CPI (Bank of Canada) experienced between the completion of the FEED study which is the basis of these estimates and the date of this report. The capital costs are summarized in **Table 21**.

Table 21. Capital cost estimates for a CVW™ installation at a 250,000 bbl/d host oil sands site. Capital costs for Phase 2 within the EcoFlex option are incremental to Phase 1.

	ECOBASE	ECOFLEX		ECOMAX
Construction – Direct	232.6	Phase 1 Phase 2	232.6 449.3	681.9
Construction – Indirect	49.0	Phase 1 Phase 2	49.0 86.4	135.3
Owner's Costs	32.3	Phase 1 Phase 2	32.3 58.1	90.4
Commissioning	11.1	Phase 1 Phase 2	11.1 11.5	22.6
Estimated Capital Cost	325.0	Phase 1 Phase 2	325.0 605.3	930.3
Contingency (20%)	65.0	Phase 1 Phase 2	65.0 121.1	186.1
Total Capital Cost Estimate	**390.0**	**Phase 1** **Phase 2**	**390.0** **726.3**	**1,116.3**

5.3.3.1. Direct Cost Components

Direct costs are comprised of the buildings, structural steel, concrete, pilings, piping and coatings as well as the installed costs of all equipment and materials. Detailed engineering expenses have also been in this category, estimated at 8% of direct costs. This level of detailed engineering is consistent with the effort required to elevate the project definition to AACE Class 2.

Direct costs relating to the MSP have been estimated using components of the AACE Class 3 capital cost estimate prepared by FWS Engineering (facilities) and IHC Robbins (process) conducted from 2020 to 2021. The estimates from these reports were considered a starting point, from which consideration was given to the variability of sites and logistics. While using conventional technologies, the mineral dressing operations have been designed to recover finer grades of valuable critical minerals utilizing gravity spirals, flotation and dry mill reprocessing.

5.3.3.2. Indirect Cost Components

Construction indirect costs include field staff, temporary construction services and supplies, construction equipment and small tools, home office costs, mobilization costs and camp/travel costs.

5.3.3.3. Owner's Costs

Owner's costs include engineering and construction management costs. Detailed engineering expenses were estimated at 8% of direct costs.

5.3.3.4. Commissioning and Start-up

Commissioning costs include an allowance for spares, while also including estimated operating expenses for a six-month period.

5.3.3.5. Contingency

The contingency of 20% has been assigned to the project's estimated capital costs. This level of contingency is consistent with rates applied in AACE Class 4 pricing estimates.

5.3.3.6. Sustaining Capital

Sustaining capital costs have been estimated at a rate of 3.3% of total direct costs for the duration of the project, after the capital construction and commissioning phases are complete.

5.4. Financial Information

All the prospective financial information contained in this document is provided for information purposes only and is subject to the assumptions set forth herein. THIS INFORMATION IS NOT INDICATIVE OF CVW CLEANTECH'S INTEREST IN OR PROSPECTIVE RETURNS IN ANY CVW™ PROJECT.

Third Party Information

Certain information contained herein includes market, third party and industry data that has been obtained from or is based upon estimates derived from third party sources, including industry publications, reports and websites. Government and industry publications and reports generally indicate that they have obtained their information from sources believed to be reliable, but CVW CleanTech has not conducted its own independent verification of such information. No representation or warranty of any kind, express or implied, is made by CVW CleanTech as to the accuracy, currency or completeness of any of the information from third party sources referred to in this document or ascertained from the underlying economic assumptions relied upon by such sources, or shall be relied upon as, a promise or re-report by CVW CleanTech.

Forward-Looking Information

This document contains forward-looking statements and information within the meaning of applicable Canadian securities laws (collectively, "**forward-looking information**" or "**forward-looking statements**") that reflect the current expectations of management about the future results, performance, achievements, prospects, or opportunities for CVW CleanTech.

Forward-looking statements are frequently, but not always, identified by words such as "expects", "anticipates", "believes", "intends", "estimates", "potential", "possible" and similar expressions, or statements that events, conditions or results "will", "may", "could" or "should" occur or be achieved. The forward-looking statements may include statements regarding the CVW™ process being ready for commercial implementation and the socio-economic benefits of a commercial deployment; the net incremental benefit of CVW™ implementation reducing site-wide oil sands emissions by 5-10% annually; estimates of methane and naphtha release reduction when CVW™ is combined with other off-gas capture technology; the sustained technology advantage of CVW™ technology due to protective patents and the time and investment required to develop similar technologies; plans for project infrastructure including access, tie-ins, fire water, electrical, control and telecom, site drainage and flare; plans for process safety; regulatory and permit requirements including statements relating to EA and Indigenous concerns; resulting benefits and implications of the implementation of the CVW™ technology relating to reduction of future methane emissions from tailings ponds, reduction of CAC emissions of VOCs and SOAs, recovery of high quality bitumen and naphtha to offset incremental emissions, opportunities for heat integration including reducing river water draw and offsetting natural gas consumption required to heat cold tailings pond water, related benefits to both land-use and water-use profiles, the recovery of critical minerals, and the production of valuable mineral concentrates; potential benefit accruing to CVW™ technology GHG emissions abatement; estimates relating to existing minerals recovered from tailings; CVW™ process GHG emission reduction estimates relating to electricity and natural gas consumption; the CVW™ technology efficiently segregating the contained pyrite enabling cost effective management of pyrite; forecasts and estimates relating to commodity recoveries, operational benefits, hydrocarbon recoveries and mineral recoveries; forecasts of tailings management capture and tailings management cost savings; expectations relating to an execution schedule, CEP, retaining expert consultants and resulting benefits of a construction management team; forecasts relating to development options and financial estimates; and other statements that are not statements of fact. Forward-looking statements are statements about the future and are inherently uncertain, and actual achievements of the Company may differ materially from those reflected in forward-looking statements due to a variety of risks, uncertainties and other factors. For the reasons set forth above, investors should not place undue reliance on forward-looking statements. Important factors that could cause actual results to differ materially from the Company's expectations include: uncertainties in the timing and receipt of regulatory and exchange approvals; uncertainties involved in disputes and litigation; fluctuations in interest rates, commodity prices, currency exchange rates, and other financial conditions, and the resultant effect on viability of investments; fluctuations in carbon tax pricing, income tax rates and provincial royalty rates; changes in the availability, and cost, of technical labour required for the CVW CleanTech business; price escalation and/ or inflationary pressures affecting the cost of equipment and material required to commercialize the CVW™ projects; the uncertainty of estimates of capital and operating costs; the need to obtain additional financing and uncertainty as to the availability and terms of future financing; the impact on the Company of increasing inflation; and other risks and uncertainties disclosed in other information released by the Company from time to time and filed with the appropriate regulatory agencies.

All forward-looking statements are based on the Company's beliefs and assumptions which are based on information available at the time these assumptions are made. In addition to other assumptions as set out in this document, the Company has made the following assumptions in relation to the forward-looking statements in this document: the expected environmental and economic benefits to be achieved from CVW™ technologies; the ability of the Company to successfully access various government funding programs; the details of government funding programs and that such programs will be implemented (and not change) as expected; that the Company will continue to be able to protect its intellectual property; assumptions as to various market and commercial opportunities for the Company and its technologies; and the ability of the Company to continue to develop and commercialize its technologies. The forward-looking statements contained herein are as of the date set out above and are subject to change after this date, and the Company assumes no obligation to publicly update or revise the statements to reflect new events or circumstances, except as may be required pursuant to applicable laws.

Although management believes that the expectations represented by such forward-looking information or statements are reasonable, there is significant risk that the forward-looking information or statements may not be achieved, and the underlying assumptions thereto will not prove to be accurate. Actual results or events could differ materially from the plans, intentions and expectations expressed or implied in any forward-looking information or statements, including the underlying assumptions thereto, as a result of numerous risks, uncertainties and factors including: failure to obtain regulatory approvals; the possibility that opportunities will arise that require more cash than the Company has or can reasonably obtain; dependence on key personnel; dependence on corporate collaborations; potential delays; uncertainties related to the early stage of technology and product development; uncertainties as to fluctuation of the stock market; uncertainties as to future expense levels and the possibility of unanticipated costs or expenses or cost overruns; and other risks and uncertainties which may not be described herein.

06

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07

Appendix

7. Appendix: Integrated Pilot

7.1. Hydrocarbon Recovery and Quality

The CVW™ Concentrator Plant of the Integrated Pilot was a nominal 5kg/min continuous demonstration of Fines Bitumen Recovery, Coarse HMC Production and Solvent Recovery circuits. Froth treatment tailings were classified into a 'Coarse' sands fraction that concentrates valuable heavy minerals and a 'Fines' stream that contains the plurality of bitumen. The Fines Bitumen Recovery circuit extracts the bitumen from the Fines stream using flotation and solvent extraction. The Coarse HMC Production circuit makes a heavy minerals concentrate via flotation from the coarse sands and then extracts residual bitumen such that it is amenable to subsequent processing in the minerals separation pilot to produce zircon. The Solvent Recovery process circuits, utilizing TDUs, removes naphtha from CVW™ raffinates and cleaned HMC while producing environmentally favourable process tailings.

Material balancing was conducted around each of the processing closures described above. To provide a precision estimate of the calculations, error models based on a propagation of error approach were utilized. To facilitate the material closure calculations, samples were collected for constituent analysis at defined intervals and relevant engineering data logged on a digital data acquisition system. Two sets of sampling campaigns – Product Quality and Material Balancing - were conducted. When the CP was in full operation – that is, when the Bitumen and Solvent Recovery modules as well as the HMC Production circuit were running steady – a material balance sampling involves the collection of 66 samples (**Table 7-1**). This was comprised of 12 separation sample points; of these, 10 points were sampled six times each for compositional analyses and two bitumen product streams were sampled in triplicate for compositional analyses.

Table 7-1. Sampling schedule for the Concentrator Plant at the Integrated Pilot operated at CanmetENERGY in Devon, AB. Note that THPPF is the analytical labeling code for the Bitumen Recovery (Fines) circuit including the Fines Solvent Recovery module. THPPC is the analytical labeling code for the HMC Production (Coarse) circuit including the Coarse Solvent Recovery module. "BMW" refers to the three component Dean-Stark Sohxlet extraction and "Diluent" refers to the gas chromatographic extractive technique to determine solvent content.

HPP Sampling Schedule

THPPF (FINES)	BMW	Diluent	Dilbit characterization	THPPC (Coarse)	BMW	Diluent	Dilbit characterization
THPPF-FEED	3	3		THPPC-FEED	3	3	
THPPF-Float Froth	3	3		THPPC-Float Froth	3	3	
THPPF-Float Tails	3	3		THPPC-Float Tails	3	3	
THPPF-CCD1-Product			3	THPPC-CCD1-Product			3
THPPF-CCD2-Tails	3	3		THPPC-CCD3-Tails	3	3	
THPPF-TSRU- Tails	3	3		THPPC-TSRU- Tails	3	3	
SubTotal	15	15		**SubTotal**	15	15	
					TOTAL # of samples		**66**

Prior to sampling, the operations were in steady state with constant flowrates and settler interfaces. All samples were taken starting from the last point in the process and finishing at the beginning, so that any process upsets from sampling were avoided. These samples were then sent out on a daily basis to a third party analytical group (Maxxam Analytics) for analyses. Material balance samples were collected every three or four hours, providing for up to 20 snapshots of process performance per week of operations. Bitumen product samples were collected weekly. Compositional data for select streams, recovery performance, representative engineering data and analytical outputs are indicated in **Tables 7-2 to 7-9** and **Figures 7-1 to 7-8** below.

Table 7-2. Select data from CVW CleanTech's Integrated Pilot Fines flotation circuit. Period represents the start date of weekly testing runs. Flowrates obtained in five second intervals over the duration of the testing period. Stream composition data obtained through sampling in triplicate every four hours of steady operation; analyses conducted by Maxxam Analytics.

Fines Flotation Feed

Period	Flow (kg/min)		Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
18/10/10	5.021	0.010	1.739	0.058	8.023	0.687	89.619	0.940
25/10/10	5.015	0.011	1.367	0.043	6.837	1.123	76.624	1.249
29/10/10	4.921	0.013	1.224	0.042	8.365	0.448	89.881	0.569
9/11/10	4.168	0.011	1.471	0.049	9.420	0.569	88.438	0.695
15/11/10	4.406	0.173	0.396	0.012	3.733	0.187	95.513	0.499
29/11/10	4.559	0.021	0.403	0.022	3.987	0.075	94.797	0.526
6/12/10	5.246	0.039	0.819	0.033	5.883	0.327	92.524	0.355
10/1/11	5.225	0.059	1.397	0.050	8.595	0.273	89.164	0.456
17/1/11	5.225	0.072	1.047	0.032	6.257	0.204	91.978	0.456
25/1/11	4.992	0.015	1.556	0.043	7.334	0.688	90.348	0.856
Average	**4.878**	**0.042**	**1.142**	**0.038**	**6.843**	**0.458**	**89.889**	**0.660**

Fines Flotation Tailings

Period	Flow (kg/min)		Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
18/10/10	1.520	0.025	0.230	0.047	6.295	0.264	93.028	0.355
25/10/10	1.527	0.043	0.263	0.040	7.318	0.953	92.041	1.067
29/10/10	1.497	0.014	0.245	0.064	7.483	0.878	91.811	0.951
9/11/10	1.491	0.014	0.251	0.026	7.923	0.759	91.273	0.852
15/11/10	1.418	0.211	0.094	0.022	3.317	0.477	96.239	0.640
29/11/10	1.383	0.055	0.110	0.022	4.487	1.177	94.955	1.399
6/12/10	1.516	0.047	0.179	0.028	5.595	0.589	93.485	0.844
10/1/11	1.499	0.063	0.571	0.043	10.695	1.956	88.467	2.003
17/1/11	1.482	0.024	0.217	0.054	6.142	0.991	92.934	9.932
25/1/11	1.518	0.022	0.332	0.044	7.317	0.528	91.875	0.621
Average	**1.485**	**0.052**	**0.249**	**0.039**	**6.653**	**0.857**	**92.611**	**1.867**

Table 7-3. Select data from CVW CleanTech's Integrated Pilot Fines solvent extraction circuit. Period represents the start date of weekly testing runs. Flowrates obtained in five second intervals over the duration of the testing period. Stream composition data obtained through sampling in triplicate every four hours of steady operation; analyses conducted by Maxxam Analytics.

Fines Solvent Extraction Feed

Period	Flow (kg/min)		Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
18/10/10	2.482	0.132	2.565	0.222	7.582	0.462	88.446	0.629
25/10/10	2.557	0.133	1.890	0.089	8.470	0.259	89.308	0.515
29/10/10	2.493	0.107	1.593	0.065	8.487	0.267	89.385	0.492
9/11/10	2.448	0.117	2.180	0.129	9.690	0.415	87.443	0.638
15/11/10	2.507	0.091	0.556	0.070	3.717	0.088	95.070	0.314
29/11/10	2.474	0.015	0.668	0.026	4.373	0.026	94.372	0.238
6/12/10	3.495	0.122	1.095	0.111	6.006	0.181	92.127	0.607
10/1/11	3.281	0.292	1.750	0.075	7.930	0.291	81.568	0.394
17/1/11	3.484	0.139	1.443	0.128	6.141	0.191	91.809	0.614
25/1/11	3.010	0.170	2.209	0.266	6.979	0.328	90.038	0.370
Average	**2.823**	**0.132**	**1.595**	**0.118**	**6.937**	**0.251**	**89.956**	**0.481**

Fines Solvent Extraction Tailings

Period	Flow (kg/min)		Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
18/10/10	2.545	0.271	0.296	0.075	7.655	0.863	89.199	1.053
25/10/10	2.416	0.186	0.229	0.046	7.907	1.932	89.323	2.215
29/10/10	2.538	0.167	0.128	0.041	7.586	0.565	90.381	0.824
9/11/10	2.551	0.179	0.140	0.033	7.692	0.450	90.699	1.156
15/11/10	2.568	0.102	0.039	0.021	3.064	0.528	96.132	0.631
29/11/10	2.514	0.119	0.061	0.031	3.452	0.260	95.707	0.485
6/12/10	3.512	0.186	0.108	0.040	5.974	0.142	92.960	0.244
10/1/11	3.519	0.198	0.233	0.022	5.128	0.140	90.857	0.329
17/1/11	3.426	0.171	0.125	0.035	5.742	0.213	92.846	0.466
25/1/11	3.081	0.193	0.230	0.050	5.874	0.441	92.243	0.903
Average	**2.867**	**0.177**	**0.159**	**0.039**	**6.007**	**0.554**	**92.035**	**0.831**

Table 7-4. Select data from CVW CleanTech's Integrated Pilot Fines solvent recovery circuit. Period represents the start date of weekly testing runs. Flowrates obtained in five second intervals over the duration of the testing period. Stream composition data obtained through sampling in triplicate every four hours of steady operation; analyses conducted by Maxxam Analytics.

Fines Solvent Recovery Feed

Period	Flow (kg/min)		Naphtha (% wt)		Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
18/10/10	2.603	0.109	4.848	0.739	0.565	0.079	7.705	0.459	85.745	1.178
25/10/10	2.498	0.187	5.530	0.775	0.453	0.088	8.059	1.488	86.202	1.950
29/10/10	2.547	0.196	7.139	1.444	0.273	0.064	8.057	0.955	86.020	1.961
9/11/10	2.509	0.214	8.128	0.488	0.845	0.189	9.743	1.094	73.652	2.760
15/11/10	2.535	0.102	0.594	0.155	0.039	0.027	3.531	0.374	95.730	0.323
29/11/10	2.490	0.103	2.513	1.528	0.137	0.023	3.973	0.206	91.147	0.704
6/12/10	3.589	0.144	3.330	0.305	0.223	0.133	7.190	2.030	88.350	4.642
10/1/11	3.527	0.203	5.819	0.609	0.447	0.056	9.163	0.242	83.842	0.818
17/1/11	3.542	0.105	2.977	1.141	0.237	0.081	5.453	0.125	90.387	0.562
25/1/11	3.088	0.286	3.720	0.915	0.456	0.069	10.572	1.262	83.878	2.193
Average	**2.893**	**0.165**	**4.460**	**0.810**	**0.367**	**0.081**	**7.345**	**0.823**	**86.495**	**1.709**

Fines Solvent Recovery Tailings

Period	Flow (kg/min)		Naphtha (% wt)		Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
18/10/10	2.587	0.337	0.205	0.037	0.564	0.060	8.234	0.127	90.506	0.356
25/10/10	2.347	0.419	0.215	0.015	0.506	0.064	7.675	0.332	80.705	0.323
29/10/10	2.285	0.287	0.080	0.000	0.094	0.053	6.279	0.296	93.195	0.175
9/11/10	2.328	0.177	0.516	0.044	0.811	0.056	9.954	0.219	87.887	0.423
15/11/10	2.706	0.133	0.080	0.000	0.050	0.034	3.600	0.075	96.113	0.254
29/11/10	2.467	0.180	0.103	0.012	0.137	0.032	3.763	0.101	95.103	0.078
6/12/10	3.977	0.087	0.220	0.010	0.240	0.000	6.810	0.044	91.927	0.176
10/1/11	3.630	0.329	0.352	0.023	0.327	0.030	8.602	0.100	90.236	0.170
17/1/11	3.540	0.028	0.080	0.000	0.167	0.025	5.773	0.240	92.943	0.513
25/1/11	3.186	0.217	0.133	0.005	0.321	0.030	7.620	0.362	91.218	0.700
Average	**2.905**	**0.220**	**0.198**	**0.015**	**0.322**	**0.038**	**6.831**	**0.190**	**90.983**	**0.317**

Table 7-5. Select data from CVW CleanTech's Integrated Pilot Coarse bulk flotation circuit. Period represents the start date of weekly testing runs. Stream composition data obtained through sampling in triplicate every four hours of steady operation; analyses conducted by Maxxam Analytics.

Fines Solvent Recovery Tailings

Period	Flow (kg/min)	Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Calc.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
15/10/12	1.538	1.290	0.028	13.129	0.912	84.854	1.016
29/10/12	1.506	0.847	0.017	13.789	0.473	85.036	0.664
5/11/12	1.486	1.227	0.035	14.419	1.271	83.682	1.429
19/11/12	1.560	1.283	0.040	14.740	0.522	83.540	0.854
26/11/12	1.483	1.624	0.083	13.555	0.507	84.225	0.550
10/12/12	1.581	1.005	0.039	16.065	0.707	82.632	0.895
17/12/12	1.501	0.765	0.017	12.863	0.229	85.991	0.389
14/1/13	1.620	0.670	0.036	13.953	0.409	85.253	0.532
21/1/13	1.507	0.991	0.030	11.437	0.498	87.232	0.645
Average	**1.531**	**1.078**	**0.036**	**13.772**	**0.614**	**84.716**	**0.775**

Fines Solvent Recovery Tailings

Period	Flow (kg/min)	Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Calc.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
15/10/12	0.777	2.307	0.156	13.460	1.119	83.583	1.279
29/10/12	0.810	1.660	0.133	15.940	1.480	82.101	1.521
5/11/12	0.664	1.093	0.046	14.219	0.159	84.299	0.385
19/11/12	0.796	1.420	0.049	15.370	0.366	82.795	0.593
26/11/12	0.700	1.953	0.087	14.143	0.644	83.366	0.773
10/12/12	0.776	1.385	0.166	15.103	1.210	83.310	1.249
17/12/12	1.041	1.313	0.085	13.837	1.084	84.301	0.966
14/1/13	0.920	1.167	0.025	13.213	0.388	85.343	0.514
21/1/13	0.785	1.580	0.193	11.656	0.598	86.381	0.601
Average	**0.808**	**1.542**	**0.104**	**14.105**	**0.783**	**83.942**	**0.876**

Table 7-6. Select data from CVW CleanTech's Integrated Pilot Coarse solvent extraction circuit. Period represents the start date of weekly testing runs. Stream composition data obtained through sampling in triplicate every four hours of steady operation; analyses conducted by Maxxam Analytics.

Coarse Bulk Flotation Feed

Period	Flow (kg/min)	Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Calc.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
15/10/12	0.777	2.307	0.156	13.460	1.119	83.583	1.279
29/10/12	0.810	1.660	0.133	15.940	1.480	82.101	1.521
5/11/12	0.664	1.093	0.046	14.219	0.159	84.299	0.385
19/11/12	0.796	1.420	0.049	15.370	0.366	82.795	0.593
26/11/12	0.700	1.953	0.087	14.143	0.644	83.366	0.773
10/12/12	0.776	1.385	0.166	15.103	1.210	83.310	1.249
17/12/12	1.041	1.313	0.085	13.837	1.084	84.301	0.966
14/1/13	0.920	1.167	0.025	13.213	0.388	85.343	0.514
21/1/13	0.785	1.580	0.193	11.656	0.598	86.381	0.601
Average	**0.808**	**1.542**	**0.104**	**14.105**	**0.783**	**83.942**	**0.876**

Coarse Bulk Solvent Extraction Tailings

Period	Flow (kg/min)	Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Calc.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
15/10/12	0.669	0.241	0.038	9.803	1.556	81.890	2.525
29/10/12	0.495	0.130	0.029	6.890	1.088	76.136	1.797
5/11/12	0.588	0.103	0.024	10.903	1.539	82.732	2.579
19/11/12	0.759	0.128	0.019	11.605	1.216	81.787	2.005
26/11/12	0.831	0.135	0.060	9.164	0.885	84.900	1.596
10/12/12	0.709	0.112	0.023	10.520	1.281	84.564	1.590
17/12/12	1.018	0.118	0.029	8.764	1.658	86.286	2.325
14/1/13	0.752	0.101	0.038	7.659	1.064	88.846	1.378
21/1/13	0.607	0.089	0.025	8.464	0.568	86.578	0.868
Average	**0.714**	**0.129**	**0.032**	**9.308**	**1.206**	**83.747**	**1.852**

Table 7-7. Select data from CVW CleanTech's Integrated Pilot Coarse solvent extraction circuit. Period represents the start date of weekly testing runs. Stream composition data obtained through sampling in triplicate every four hours of steady operation; analyses conducted by Maxxam Analytics.

Coarse Solvent Recovery Feed

Period	Flow (kg/min)	Naphtha (% wt)		Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Calc.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
15/10/12	0.732	8.549	0.479	0.275	0.037	10.130	1.491	81.063	2.314
29/10/12	0.525	5.847	0.839	0.127	0.029	7.213	1.237	73.728	1.889
5/11/12	0.588	5.420	0.758	0.103	0.024	10.903	1.539	82.732	2.579
19/11/12	0.775	6.392	1.085	0.132	0.018	11.800	1.212	81.456	1.988
26/11/12	0.831	5.376	0.539	0.135	0.060	9.164	0.885	84.900	1.596
10/12/12	0.709	5.542	0.707	0.112	0.023	10.520	1.281	84.564	1.590
17/12/12	1.114	4.030	0.489	0.135	0.026	12.344	1.361	82.728	2.092
14/1/13	0.736	4.392	0.282	0.119	0.043	9.656	1.709	85.868	2.189
21/1/13	0.607	5.183	0.542	0.089	0.025	8.464	0.568	86.578	0.868
Average	**0.735**	**5.637**	**0.636**	**0.137**	**0.032**	**10.022**	**1.254**	**82.624**	**1.901**

Coarse Solvent Recovery Tailings

Period	Flow (kg/min)	Naphtha (% wt)		Bitumen (%wt)		Minerals (%wt)		Water (%wt)	
DD/MM/YY	Calc.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
15/10/12	0.750	0.080	0.000	0.210	0.040	6.157	1.630	93.327	1.647
29/10/12	0.286	0.080	0.000	0.141	0.035	11.898	1.360	86.901	1.361
5/11/12	0.376	0.080	0.000	0.119	0.031	6.226	1.647	93.389	1.745
19/11/12	0.509	0.080	0.000	0.134	0.036	14.333	3.103	85.354	3.181
26/11/12	0.754	0.080	0.000	0.110	0.027	8.144	2.807	91.322	2.873
10/12/12	0.598	0.080	0.000	0.067	0.023	3.678	1.338	95.991	1.340
17/12/12	0.812	0.080	0.000	0.095	0.040	4.991	4.085	94.673	4.134
14/1/13	0.610	0.080	0.000	0.075	0.026	3.400	0.436	96.160	0.639
21/1/13	0.435	0.080	0.000	0.079	0.033	2.751	0.313	96.707	0.447
Average	**0.570**	**0.080**	**0.000**	**0.114**	**0.032**	**6.842**	**1.858**	**92.647**	**1.930**

Table 7-8. Summary of Hydrocarbon Performance of the CVW^{TM} Fines Circuit at the Integrated Demonstration Pilot. Calculations based on feed and tailings of each circuit per operating period.

CVW^{TM} Fines Circuit Hydrocarbon Recovery Performance – Integrated Pilot

	Bitumen						Naphtha	
Period	Flotation		Solvent Extraction		Net Recovery		TDU	
DD/MM/YY	% wt.	Cum. Err.	% wt.	Cum. Err.	% wt.	Cum. Err.	% wt.	Cum. Err.
18/10/10	95.994	9.252	88.167	7.091	84.635	10.624	95.795	16.834
25/10/10	94.147	4.789	88.531	4.983	83.349	6.323	96.339	17.877
29/10/10	93.901	4.972	91.798	5.557	86.199	6.933	98.995	18.941
9/11/10	93.897	4.855	93.310	7.627	87.616	8.474	94.107	12.658
15/11/10	92.315	8.333	92.886	4.860	85.748	8.947	85.639	24.858
29/11/10	91.727	7.521	90.799	5.941	83.287	8.737	95.927	13.965
6/12/10	93.677	5.874	90.053	5.677	84.359	7.501	92.680	9.856
10/1/11	88.262	5.469	85.698	5.006	75.638	6.441	93.770	11.995
17/1/11	94.129	5.389	91.481	5.982	86.110	7.484	97.314	39.371
25/1/11	93.523	4.024	89.319	5.390	83.533	6.191	96.325	27.083
Average	**93.157**	**6.048**	**90.204**	**5.811**	**84.982**	**7.750**	**95.695**	**18.731**

Table 7-9. Summary of Hydrocarbon Performance of the CVW^{TM} Coarse Circuit at the Integrated Demonstration Pilot. Calculations based on feed and tailings of each circuit per operating period.

CVW^{TM} Coarse Circuit Hydrocarbon Recovery Performance – Integrated Pilot

	Bitumen						Naphtha	
Period	Flotation		Solvent Extraction		Net Recovery		TDU	
DD/MM/YY	% wt.	Cum. Err.	% wt.	Cum. Err.	% wt.	Cum. Err.	% wt.	Cum. Err.
15/10/12	93.936	3.427	91.011	3.248	85.492	4.363	99.041	2.504
29/10/12	92.149	2.919	95.216	6.845	87.741	6.893	99.255	3.661
5/11/12	95.336	4.465	91.626	3.859	87.352	5.502	99.055	4.501
19/11/12	94.578	4.388	91.368	3.346	86.414	5.108	99.177	7.315
26/11/12	94.549	5.716	91.769	4.053	86.767	6.496	98.650	6.905
10/12/12	92.807	5.770	92.623	4.236	85.960	6.634	98.782	6.436
17/12/12	92.235	5.987	91.249	5.527	84.163	7.472	98.553	5.550
14/1/13	90.068	7.277	92.891	3.880	83.665	7.610	98.490	4.814
21/1/13	92.639	2.886	95.623	6.372	88.584	6.516	98.894	6.176
Average	**93.144**	**4.759**	**92.597**	**4.596**	**86.249**	**6.144**	**98.878**	**5.318**

Maxxam

CERTIFICATE OF ANALYSIS

MaxxID	TITAN03CE
Client ID	
Meter Number	
Laboratory Number	B0B0832:Y40698
Operator Name	TITANIUM CORPORATION
LSD	
Well ID	
Well Name	PILOT PLANT
Initials of Sampler	C1
Sampling Company	TITANIUM
Field or Area	
Pool or Zone	
Sample Point	THPPF-FEED
Container Identity	GLASS BOTTLE
Percent Full	
Test Recovery	
Test Type	
No.	
Multiple Recovery	
Interval From: / To:	
Elevations (m) KB / GRD	
Sample Gathering Point	
Solution Gas	
Well Fluid Status	
Well Status Mode	
Production Rates: Water m3/d / Oil m3/d / Gas 1000m3/d	
Gauge Pressures kPa: Source / As Received	
Temperature °C: Source / As Received	23.0 (As Received)
Well Status Type	
Well Type	
Gas or Condensate Project	
Licence No.	
Date Sampled Start	2010/11/11 00:00
Date Sampled End	
Date Received	2010/11/12
Date Reported	2010/11/18
Date Reissued	2010/11/18
Analyst	MN2,LUL,SP4

PARAMETER DESCRIPTION	Result	unit		MDL
Physical Properties				
Measured Flow Rate	5.0	kg/min		0.1
Dean Stark Analysis				
Mass Bitumen	3.27	g	OSRD Method 1.0	0.01
Mass Solids	19.35	g	OSRD Method 1.0	0.01
Mass Water	234.91	g	OSRD Method 1.0	0.01
Mass Total	262.56	g	OSRD Method 1.0	0.01
Mass % Bitumen	1.25	wt%	OSRD Method 1.0	0.01
Mass % Solids	7.37	wt%	OSRD Method 1.0	0.01
Mass % Water	89.47	wt%	OSRD Method 1.0	0.01
Mass % Recovery	98.08	wt%	OSRD Method 1.0	0.01
Gas Chromatography				
Diluent Content	0.09	mass%	EIND SOP - 00264	0.08

** Information not supplied by client – data derived from LSD information

Results relate only to items tested

Remarks:

CALGARY 2021-41 Avenue N.E., Calgary, Canada T2E 6P2 Tel: (403) 291-3077 Fax (403) 291-9468
EDMONTON 6744-50 Street, Edmonton, Canada T6B 3M9 Tel: (780) 378-8500 Fax (780) 378-8699
GRANDE PRAIRIE #101, 7002 - 98 Street, Clairmont, Canada T0H 0W0 Tel: (780) 532-0227 Fax (780) 532-0288
RED DEER Bay #3, 4845 79 Street, Red Deer, Canada T4P 2T4 Tel: (403) 341-8811 Fax (403) 341-8815

2010/11/18 16:56

Figure 7.1. Typical compositional analytical output for the Fines circuit feed stream.

Maxxam

CERTIFICATE OF ANALYSIS

MaxxID	TITAN04CE
Client ID	
Meter Number	
Laboratory Number	B0B0705:Y39600
Operator Name	TITANIUM CORPORATION
LSD	
Well ID	
Well Name	PILOT PLANT
Initials of Sampler	N/A
Sampling Company	TITANIUM
Field or Area	
Pool or Zone	
Sample Point	THPPF-FLOAT FROTH
Container Identity	GLASS BOTTLE
Percent Full	
Test Recovery	
Test Type / No. / Multiple Recovery	
Interval From: / To:	
Elevations (m) KB / GRD	
Sample Gathering Point	
Solution Gas	
Well Fluid Status	
Well Status Mode	
Production Rates: Water m3/d / Oil m3/d / Gas 1000m3/d	
Gauge Pressures kPa: Source / As Received	
Temperature °C: Source / As Received	23.0
Well Status Type	
Well Type	
Gas or Condensate Project	
Licence No.	
Date Sampled Start	2010/11/10 21:00
Date Sampled End	
Date Received	2010/11/12
Date Reported	2010/11/17
Date Reissued	2010/11/18
Analyst	MM1,LUL,SP4

PARAMETER DESCRIPTION	Result	unit		MDL
Physical Properties				
Measured Flow Rate	2.5	kg/min		0.1
Dean Stark Analysis				
Mass Bitumen	3.44	g	OSRD Method 1.0	0.01
Mass Solids	29.03	g	OSRD Method 1.0	0.01
Mass Water	209.04	g	OSRD Method 1.0	0.01
Mass Total	241.67	g	OSRD Method 1.0	0.01
Mass % Bitumen	1.42	wt%	OSRD Method 1.0	0.01
Mass % Solids	12.01	wt%	OSRD Method 1.0	0.01
Mass % Water	86.50	wt%	OSRD Method 1.0	0.01
Mass % Recovery	99.93	wt%	OSRD Method 1.0	0.01
Gas Chromatography				
Diluent Content	<0.08	mass%	EIND SOP - 00264	0.08

** Information not supplied by client – data derived from LSD information

Results relate only to items tested

Remarks:

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2010/11/18 10:05

Figure 7-2. Typical compositional analytical output for the Fines circuit flotation froth stream.

Maxxam

CERTIFICATE OF ANALYSIS

MaxxID	TITAN05CE
Client ID	
Meter Number	
Laboratory Number	B0B0705:Y39602
Operator Name	TITANIUM CORPORATION
LSD	
Well ID	
Well Name	PILOT PLANT
Initials of Sampler	N/A
Sampling Company	TITANIUM
Field or Area	
Pool or Zone	
Sample Point	THPPF-FLOAT TAILS
Container Identity	GLASS BOTTLE
Percent Full	
Test Recovery	
Test Type	
No.	
Multiple Recovery	
Interval From: / To:	
Elevations (m) KB / GRD	
Sample Gathering Point	
Solution Gas	
Well Fluid Status	
Well Status Mode	
Production Rates: Water m3/d / Oil m3/d / Gas 1000m3/d	
Gauge Pressures kPa: Source / As Received	
Temperature °C: Source / As Received	23.0 (As Received)
Well Status Type	
Well Type	
Gas or Condensate Project	
Licence No.	
Date Sampled Start	2010/11/10 21:00
Date Sampled End	
Date Received	2010/11/12
Date Reported	2010/11/17
Date Reissued	2010/11/18
Analyst	MM1,LUL,SP4

PARAMETER DESCRIPTION	Result	unit		MDL
Physical Properties				
Measured Flow Rate	1.5	kg/min		0.1
Dean Stark Analysis				
Mass Bitumen	0.37	g	OSRD Method 1.0	0.01
Mass Solids	25.20	g	OSRD Method 1.0	0.01
Mass Water	203.21	g	OSRD Method 1.0	0.01
Mass Total	229.31	g	OSRD Method 1.0	0.01
Mass % Bitumen	0.16	wt%	OSRD Method 1.0	0.01
Mass % Solids	10.99	wt%	OSRD Method 1.0	0.01
Mass % Water	88.62	wt%	OSRD Method 1.0	0.01
Mass % Recovery	99.77	wt%	OSRD Method 1.0	0.01
Gas Chromatography				
Diluent Content	<0.08	mass%	EIND SOP - 00264	0.08

** Information not supplied by client – data derived from LSD information

Results relate only to items tested

Remarks:

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RED DEER Bay #3, 4845 79 Street, Red Deer, Canada T4P 2T4 Tel: (403) 341-8811 Fax (403) 341-8815

2010/11/18 10:05

Figure 7-3. Typical compositional analytical output for the Fines circuit flotation tailings stream.

Maxxam

CERTIFICATE OF ANALYSIS

MaxxID	TITAN07CE
Client ID	
Meter Number	
Laboratory Number	B0B0832:Y40711
Operator Name	TITANIUM CORPORATION
LSD	
Well ID	
Well Name	PILOT PLANT
Initials of Sampler	C1
Sampling Company	TITANIUM
Field or Area	
Pool or Zone	
Sample Point	THPPF-CCD2-TAILS
Container Identity	GLASS BOTTLE
Percent Full	
Test Recovery	
Test Type	
No.	
Multiple Recovery	
Interval From: / To:	
Elevations (m) KB / GRD	
Sample Gathering Point	
Solution Gas	
Well Fluid Status	
Well Status Mode	
Production Rates: Water m3/d / Oil m3/d / Gas 1000m3/d	
Gauge Pressures kPa: Source / As Received	
Temperature °C: Source / As Received	23.0
Well Status Type	
Well Type	
Gas or Condensate Project	
Licence No.	
Date Sampled Start	2010/11/11 00:00
Date Sampled End	
Date Received	2010/11/12
Date Reported	2010/11/18
Date Reissued	2010/11/18
Analyst	MN2,LUL,SP4

PARAMETER DESCRIPTION	Result	unit		MDL
Physical Properties				
Measured Flow Rate	2.5	kg/min		0.1
Dean Stark Analysis				
Mass Bitumen	0.64	g	OSRD Method 1.0	0.01
Mass Solids	17.79	g	OSRD Method 1.0	0.01
Mass Water	214.14	g	OSRD Method 1.0	0.01
Mass Total	239.29	g	OSRD Method 1.0	0.01
Mass % Bitumen	0.27	wt%	OSRD Method 1.0	0.01
Mass % Solids	7.43	wt%	OSRD Method 1.0	0.01
Mass % Water	89.49	wt%	OSRD Method 1.0	0.01
Mass % Recovery	97.19	wt%	OSRD Method 1.0	0.01
Gas Chromatography				
Diluent Content	2.50	mass%	EIND SOP - 00264	0.08

** Information not supplied by client – data derived from LSD information

Results relate only to items tested

Remarks:

CALGARY 2021-41 Avenue N.E., Calgary, Canada T2E 6P2 Tel: (403) 291-3077 Fax (403) 291-9468
EDMONTON 6744-50 Street, Edmonton, Canada T6B 3M9 Tel: (780) 378-8500 Fax (780) 378-8699
GRANDE PRAIRIE #101, 7002 - 98 Street, Clairmont, Canada T0H 0W0 Tel: (780) 532-0227 Fax (780) 532-0288
RED DEER Bay #3, 4845 79 Street, Red Deer, Canada T4P 2T4 Tel: (403) 341-8811 Fax (403) 341-8815

2010/11/18 16:56

Figure 7-4. Typical compositional analytical output for Fines solvent extraction tailings.

Maxxam

CERTIFICATE OF ANALYSIS

MaxxID	TITAN08CE
Client ID	
Meter Number	
Laboratory Number	B0B0832:Y40714
Operator Name	TITANIUM CORPORATION
LSD	
Well ID	
Well Name	PILOT PLANT
Initials of Sampler	C1
Sampling Company	TITANIUM
Field or Area	
Pool or Zone	
Sample Point	THPPF-TSRU- TAILS
Container Identity	GLASS BOTTLE
Percent Full	
Test Recovery	
Test Type	
No.	
Multiple Recovery	
Interval From: / To:	
Elevations (m) KB / GRD	
Sample Gathering Point	
Solution Gas	
Well Fluid Status	
Well Status Mode	
Production Rates: Water m3/d / Oil m3/d / Gas 1000m3/d	
Gauge Pressures kPa: Source / As Received	
Temperature °C: Source / As Received	23.0
Well Status Type	
Well Type	
Gas or Condensate Project	
Licence No.	
Date Sampled Start	2010/11/11 00:00
Date Sampled End	
Date Received	2010/11/12
Date Reported	2010/11/18
Date Reissued	2010/11/18
Analyst	MN2,LUL,SP4

PARAMETER DESCRIPTION	Result	unit		MDL
Physical Properties				
Measured Flow Rate	2.5	kg/min		0.1
Dean Stark Analysis				
Mass Bitumen	0.30	g	OSRD Method 1.0	0.01
Mass Solids	16.47	g	OSRD Method 1.0	0.01
Mass Water	215.52	g	OSRD Method 1.0	0.01
Mass Total	233.20	g	OSRD Method 1.0	0.01
Mass % Bitumen	0.13	wt%	OSRD Method 1.0	0.01
Mass % Solids	7.06	wt%	OSRD Method 1.0	0.01
Mass % Water	92.42	wt%	OSRD Method 1.0	0.01
Mass % Recovery	99.61	wt%	OSRD Method 1.0	0.01
Gas Chromatography				
Diluent Content	<0.08	mass%	EIND SOP - 00264	0.08

** Information not supplied by client – data derived from LSD information

Results relate only to items tested

Remarks:

CALGARY 2021-41 Avenue N.E., Calgary, Canada T2E 6P2 Tel: (403) 291-3077 Fax (403) 291-9468
EDMONTON 6744-50 Street, Edmonton, Canada T6B 3M9 Tel: (780) 378-8500 Fax (780) 378-8699
GRANDE PRAIRIE #101, 7002 - 98 Street, Clairmont, Canada T0H 0W0 Tel: (780) 532-0227 Fax (780) 532-0288
RED DEER Bay #3, 4845 79 Street, Red Deer, Canada T4P 2T4 Tel: (403) 341-8811 Fax (403) 341-8815

2010/11/18 16:56

Figure 7-5. Typical compositional analytical output for Fines solvent recovery tailings.

MaxXam — CERTIFICATE OF ANALYSIS

MaxxID	TITAN19CE
Client ID	
Meter Number	
Laboratory Number	B093502:X32805
Operator Name	TITANIUM CORPORATION
Well Name	PILOT PLANT
LSD	
Initials of Sampler	N/A
Well ID	
Sampling Company	TITANIUM
Field or Area	
Pool or Zone	
Sample Point	THPPF-CCD1-PRODUCT (D1160 @200C)
Container Identity	GLASS BOTTLE
Percent Full	
Temperature °C	23.0
Date Sampled Start	2010/09/20 12:00
Date Sampled End	
Date Received	2010/09/30
Date Reported	2010/10/20
Date Reissued	2010/10/20
Analyst	HF ,VK ,GD ,NJ ,JM4,MH3,JL7,WH ,RN ,SM1

PARAMETER DESCRIPTION	Result	unit		MDL
Composition				
Aromatics	37.55	mass%	ASTM D2007	
Polars	39.21	mass%	ASTM D2007	
Saturates	23.24	mass%	ASTM D2007	
Composition				
Salt Content	0.0002	wt%	ASTM D6470	0.0002
Density Analysis				
Extrapolated Absolute Density @ 15°C	1004.4	kg/m3	N/A	0.1
Absolute Density @ 40°C	988.3	kg/m3	ASTM D5002	0.1
Absolute Density @ 60°C	975.1	kg/m3	ASTM D5002	0.1
Absolute Density @ 80°C	962.4	kg/m3	ASTM D5002	0.1
Distillation Analysis				
Initial Boiling Point	27.00	°C	ASTM D5236	0.1000
Final Boiling Point	160.0	°C	ASTM D5236	0.1000
Elemental Analysis				
Carbon (C)	76.17	mass%	ASTM D5291	0.01
Hydrogen	9.65	mass%	ASTM D5291	0.01
Nitrogen	0.25	mass%	ASTM D5291	0.01
Misc. Inorganics				
Total Aluminum (Al)	1.90	mg/kg	ASTM D5708B	0.100
Total Barium (Ba)	2.19	mg/kg	ASTM D5708B	0.0100
Total Calcium (Ca)	40.1	mg/kg	ASTM D5708B	0.0500
Total Cadmium (Cd)	<0.0100	mg/kg	ASTM D5708B	0.0100
Total Cobalt (Co)	<0.100	mg/kg	ASTM D5708B	0.100
Total Chromium (Cr)	0.200	mg/kg	ASTM D5708B	0.100
Total Copper (Cu)	0.296	mg/kg	ASTM D5708B	0.100
Total Iron (Fe)	9.86	mg/kg	ASTM D5708B	0.0100
Total Potassium (K)	1.85	mg/kg	ASTM D5708B	0.200
Total Magnesium (Mg)	2.02	mg/kg	ASTM D5708B	0.100
Total Manganese (Mn)	2.79	mg/kg	ASTM D5708B	0.0100
Total Molybdenum (Mo)	5.40	mg/kg	ASTM D5708B	0.0100

** Information not supplied by client – data derived from LSD information

Results relate only to items tested

Remarks:
Total metals analysis in oils and waste oils are by wet ash preparation.
Salt as NaCl (by Chloride Titration)

MaxXam — CERTIFICATE OF ANALYSIS

MaxxID	TITAN19CE
Client ID	
Meter Number	
Laboratory Number	B093502:X32805
Operator Name	TITANIUM CORPORATION
Well Name	PILOT PLANT
LSD	
Initials of Sampler	N/A
Well ID	
Sampling Company	TITANIUM
Field or Area	
Pool or Zone	
Sample Point	THPPF-CCD1-PRODUCT (D1160 @200C)
Container Identity	GLASS BOTTLE
Percent Full	
Temperature °C	23.0
Date Sampled Start	2010/09/20 12:00
Date Sampled End	
Date Received	2010/09/30
Date Reported	2010/10/20
Date Reissued	2010/10/20
Analyst	HF ,VK ,GD ,NJ ,JM4,MH3,JL7,WH ,RN ,SM1

PARAMETER DESCRIPTION	Result	unit		MDL
Misc. Inorganics				
Total Sodium (Na)	<0.100	mg/kg	ASTM D5708B	0.100
Total Nickel (Ni)	6.04	mg/kg	ASTM D5708B	0.0100
Total Phosphorus (P)	2.86	mg/kg	ASTM D5708B	0.500
Total Lead (Pb)	<0.100	mg/kg	ASTM D5708B	0.100
Total Antimony (Sb)	<0.100	mg/kg	ASTM D5708B	0.100
Total Silicon (Si)	<0.100	mg/kg	ASTM D5708B	0.100
Total Tin (Sn)	<0.100	mg/kg	ASTM D5708B	0.100
Total Strontium (Sr)	1.18	mg/kg	ASTM D5708B	0.100
Total Titanium (Ti)	2.19	mg/kg	ASTM D5708B	0.100
Total Vanadium (V)	145	mg/kg	ASTM D5708B	0.100
Total Zinc (Zn)	0.847	mg/kg	ASTM D5708B	0.100
Physical Properties				
Acid Number	2.24	mgKOH/g	ASTM D664	0.10
Ash Content	0.14	mass%	ASTM D482	0.001
C5 Insoluble Asphaltene Content	18.7	mass%	Syncrude Laboratory	0.01
Micro Carbon Residue	12.7	mass%	ASTM D4530	0.010
Total Sulphur (S)	4.84	mass%	ASTM D4294	0.005
Simulated Dist ASTM D7169				
Initial Boiling Point	174.5	°C	ASTM D7169	
1 % off	188.4	°C	ASTM D7169	
2 % off	207.7	°C	ASTM D7169	
3 % off	232.1	°C	ASTM D7169	
4 % off	252.7	°C	ASTM D7169	
5 % off	267.2	°C	ASTM D7169	
6 % off	279.6	°C	ASTM D7169	
7 % off	290.4	°C	ASTM D7169	
8 % off	299.7	°C	ASTM D7169	
9 % off	308.0	°C	ASTM D7169	
10 % off	315.7	°C	ASTM D7169	
11 % off	323.3	°C	ASTM D7169	
12 % off	330.5	°C	ASTM D7169	
13 % off	337.5	°C	ASTM D7169	
14 % off	344.4	°C	ASTM D7169	
15 % off	350.9	°C	ASTM D7169	
16 % off	357.3	°C	ASTM D7169	
17 % off	363.7	°C	ASTM D7169	

** Information not supplied by client – data derived from LSD information

Results relate only to items tested

Remarks:
Total metals analysis in oils and waste oils are by wet ash preparation.
Salt as NaCl (by Chloride Titration)

Figure 7-6. Typical compositional analytical output for Fines bitumen product.

Maxxam — **CERTIFICATE OF ANALYSIS**

Laboratory Number: B096509:X51808

Operator Name: TITANIUM CORPORATION
Well Name: TITANIUM PILOT PLANT
Initials of Sampler: KM
Sampling Company: TITANIUM
Sample Point: COARSE TRAIN TSRU SOLVENT
Container Identity: GLASS BOTTLE
Temperature °C (As Received): 23.0
Date Sampled Start: 2010/09/08 22:40 | Date Received: 2010/10/07 | Date Reported: 2010/10/20 | Date Reissued: 2010/10/20 | Analyst: SK1,RN

PARAMETER DESCRIPTION	Result	unit		MDL
Density Analysis				
API Gravity @ 15 °C	64.2	N/A		
Measured Relative Density @ 15 °C	0.7231	N/A	ASTM D4052	
Absolute Density @ 15 °C	722.4	kg/m3		0.1
Hydrocarbons				
See Attachment	SEE BELOW	N/A		
Simulated Dist ASTM D2887				
Initial Boiling Point	19.90	°C	ASTM D2887	
1 % off	21.70	°C	ASTM D2887	
2 % off	22.20	°C	ASTM D2887	
3 % off	22.70	°C	ASTM D2887	
4 % off	30.50	°C	ASTM D2887	
5 % off	31.40	°C	ASTM D2887	
6 % off	32.40	°C	ASTM D2887	
7 % off	35.30	°C	ASTM D2887	
8 % off	35.80	°C	ASTM D2887	
9 % off	36.20	°C	ASTM D2887	
10 % off	36.60	°C	ASTM D2887	
11 % off	48.60	°C	ASTM D2887	
12 % off	54.20	°C	ASTM D2887	
13 % off	55.50	°C	ASTM D2887	
14 % off	56.90	°C	ASTM D2887	
15 % off	61.30	°C	ASTM D2887	
16 % off	66.80	°C	ASTM D2887	
17 % off	67.80	°C	ASTM D2887	
18 % off	68.60	°C	ASTM D2887	
19 % off	69.00	°C	ASTM D2887	
20 % off	69.50	°C	ASTM D2887	
21 % off	74.70	°C	ASTM D2887	
22 % off	75.40	°C	ASTM D2887	
23 % off	76.10	°C	ASTM D2887	
24 % off	82.10	°C	ASTM D2887	
25 % off	84.90	°C	ASTM D2887	
26 % off	86.60	°C	ASTM D2887	
27 % off	88.30	°C	ASTM D2887	
28 % off	89.70	°C	ASTM D2887	
29 % off	91.40	°C	ASTM D2887	

** Information not supplied by client – data derived from LSD information. Results relate only to items tested

Remarks:
See attached PONA analysis.

Maxxam — **CERTIFICATE OF ANALYSIS**

Laboratory Number: B096509:X51808
Operator Name: TITANIUM CORPORATION
Well Name: TITANIUM PILOT PLANT
Initials of Sampler: KM
Sampling Company: TITANIUM
Sample Point: COARSE TRAIN TSRU SOLVENT
Container Identity: GLASS BOTTLE
Temperature °C (As Received): 23.0
Date Sampled Start: 2010/09/08 22:40 | Date Received: 2010/10/07 | Date Reported: 2010/10/20 | Date Reissued: 2010/10/20 | Analyst: SK1,RN

PARAMETER DESCRIPTION	Result	unit		MDL
Simulated Dist ASTM D2887				
30 % off	93.10	°C	ASTM D2887	
31 % off	94.70	°C	ASTM D2887	
32 % off	97.30	°C	ASTM D2887	
33 % off	97.90	°C	ASTM D2887	
34 % off	98.30	°C	ASTM D2887	
35 % off	98.60	°C	ASTM D2887	
36 % off	98.90	°C	ASTM D2887	
37 % off	102.5	°C	ASTM D2887	
38 % off	103.1	°C	ASTM D2887	
39 % off	103.5	°C	ASTM D2887	
40 % off	104.0	°C	ASTM D2887	
41 % off	105.5	°C	ASTM D2887	
42 % off	106.5	°C	ASTM D2887	
43 % off	108.7	°C	ASTM D2887	
44 % off	111.6	°C	ASTM D2887	
45 % off	112.1	°C	ASTM D2887	
46 % off	112.5	°C	ASTM D2887	
47 % off	113.1	°C	ASTM D2887	
48 % off	114.6	°C	ASTM D2887	
49 % off	115.1	°C	ASTM D2887	
50 % off	115.5	°C	ASTM D2887	
51 % off	115.9	°C	ASTM D2887	
52 % off	116.4	°C	ASTM D2887	
53 % off	117.3	°C	ASTM D2887	
54 % off	117.9	°C	ASTM D2887	
55 % off	118.5	°C	ASTM D2887	
56 % off	119.3	°C	ASTM D2887	
57 % off	121.5	°C	ASTM D2887	
58 % off	122.4	°C	ASTM D2887	
59 % off	123.4	°C	ASTM D2887	
60 % off	124.7	°C	ASTM D2887	
61 % off	125.1	°C	ASTM D2887	
62 % off	125.4	°C	ASTM D2887	
63 % off	125.7	°C	ASTM D2887	
64 % off	125.8	°C	ASTM D2887	
65 % off	126.0	°C	ASTM D2887	
66 % off	126.3	°C	ASTM D2887	
67 % off	127.0	°C	ASTM D2887	
68 % off	130.7	°C	ASTM D2887	
69 % off	132.3	°C	ASTM D2887	

** Information not supplied by client – data derived from LSD information. Results relate only to items tested

Remarks:
See attached PONA analysis.

Maxxam — **CERTIFICATE OF ANALYSIS**

Laboratory Number: B096509:X51808
Operator Name: TITANIUM CORPORATION
Well Name: TITANIUM PILOT PLANT
Initials of Sampler: KM
Sampling Company: TITANIUM
Sample Point: COARSE TRAIN TSRU SOLVENT
Container Identity: GLASS BOTTLE
Temperature °C (As Received): 23.0
Date Sampled Start: 2010/09/08 22:40 | Date Received: 2010/10/07 | Date Reported: 2010/10/20 | Date Reissued: 2010/10/20 | Analyst: SK1,RN

PARAMETER DESCRIPTION	Result	unit		MDL
Simulated Dist ASTM D2887				
70 % off	132.8	°C	ASTM D2887	
71 % off	133.3	°C	ASTM D2887	
72 % off	134.0	°C	ASTM D2887	
73 % off	135.0	°C	ASTM D2887	
74 % off	137.0	°C	ASTM D2887	
75 % off	137.7	°C	ASTM D2887	
76 % off	138.9	°C	ASTM D2887	
77 % off	139.3	°C	ASTM D2887	
78 % off	139.6	°C	ASTM D2887	
79 % off	140.0	°C	ASTM D2887	
80 % off	140.7	°C	ASTM D2887	
81 % off	141.5	°C	ASTM D2887	
82 % off	142.5	°C	ASTM D2887	
83 % off	143.5	°C	ASTM D2887	
84 % off	144.6	°C	ASTM D2887	
85 % off	145.4	°C	ASTM D2887	
86 % off	146.6	°C	ASTM D2887	
87 % off	148.5	°C	ASTM D2887	
88 % off	150.4	°C	ASTM D2887	
89 % off	150.8	°C	ASTM D2887	
90 % off	151.2	°C	ASTM D2887	
91 % off	153.8	°C	ASTM D2887	
92 % off	157.5	°C	ASTM D2887	
93 % off	160.0	°C	ASTM D2887	
94 % off	162.1	°C	ASTM D2887	
95 % off	165.4	°C	ASTM D2887	
96 % off	169.2	°C	ASTM D2887	
97 % off	174.1	°C	ASTM D2887	
98 % off	181.4	°C	ASTM D2887	
99 % off	195.4	°C	ASTM D2887	
Final Boiling Point	203.4	°C	ASTM D2887	
Viscosity Analysis				
Kinematic Viscosity @ 15°C	0.65	cSt	ASTM D445	0.01
Kinematic Viscosity @ 25°C	0.5795	cSt	ASTM D445	0.01000
Kinematic Viscosity @ 20°C	0.61	cSt	ASTM D445	0.01

** Information not supplied by client – data derived from LSD information. Results relate only to items tested

Remarks:
See attached PONA analysis.

B096509-X51807

IDENTIFIED COMPONENT GROUP CONCENTRATIONS

Component	Weight %	Liquid Volume %	Mole %
Paraffins	21.94	23.42	22.18
isoParaffins	32.02	33.53	30.31
Olefins	3.79	3.85	3.50
Naphthenes	23.30	22.57	24.67
Aromatics	18.19	15.87	18.79
Oxygenates	<0.01	<0.01	<0.01

UNIDENTIFIED COMPONENT GROUP CONCENTRATIONS

Component	Weight %	Liquid Volume %	Mole %
C4 Unknowns	<0.01	<0.01	<0.01
C5 Unknowns	<0.01	<0.01	<0.01
C6 Unknowns	<0.01	<0.01	<0.01
C7 Unknowns	<0.01	<0.01	<0.01
C8 Unknowns	<0.01	<0.01	<0.01
C9 Unknowns	<0.01	<0.01	<0.01
C10 Unknowns	0.31	0.32	0.25
C11 Unknowns	0.09	0.09	0.06
C12 Unknowns	0.12	0.12	0.08
C13 Unknowns	0.21	0.21	0.14
C14 Unknowns	0.02	0.02	0.01
C15 Unknowns	<0.01	<0.01	<0.01
C15+ Unknowns	<0.01	<0.01	<0.01

**Detection Limit: 0.01

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Figure 7-7. Typical compositional analytical output for recovered solvent product.

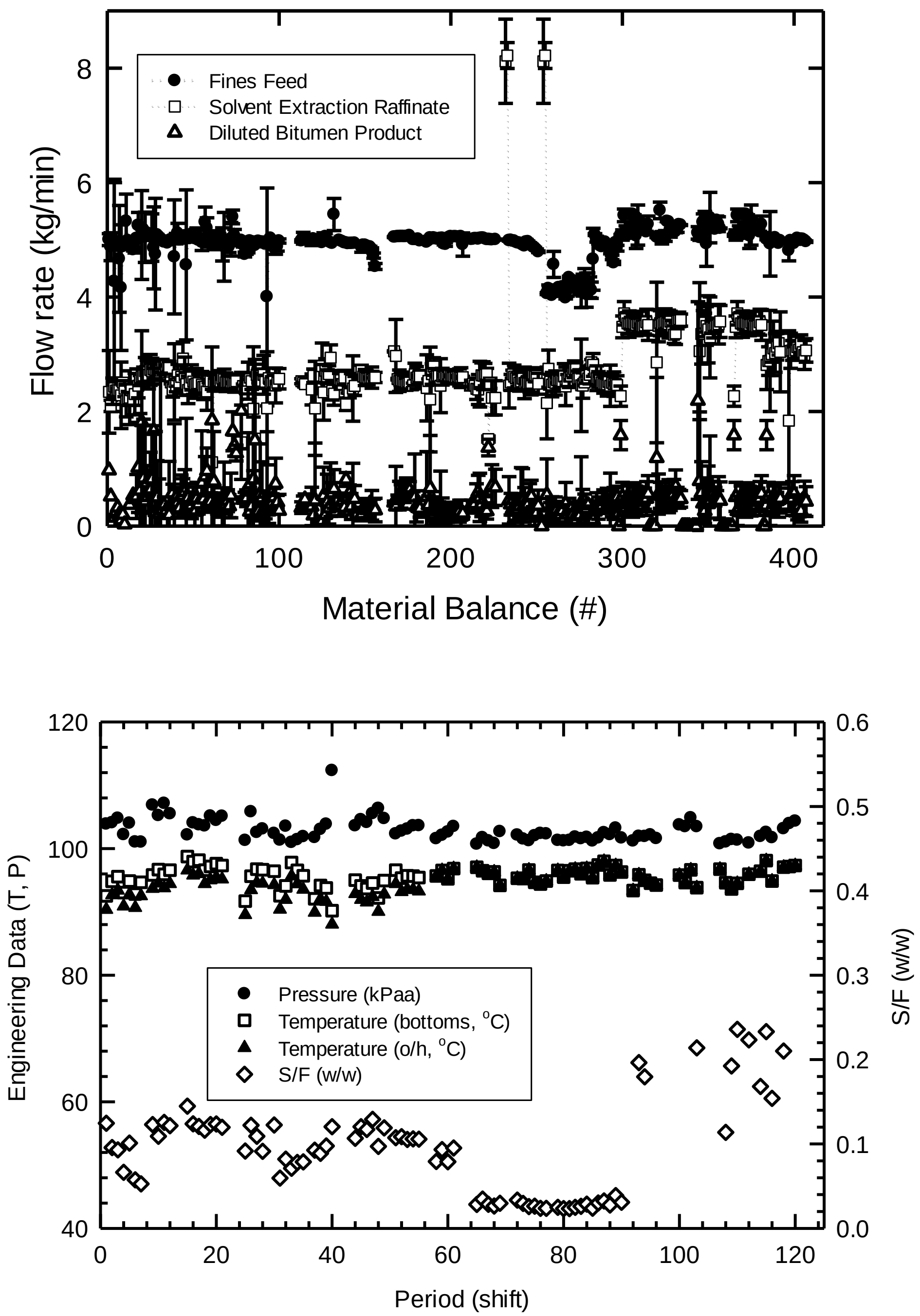

Figure 7.8. Typical process engineering data from the CVW CleanTech Integrated Pilot.*a* Top: Select Fines circuit streams. Bottom: Tailings Distillation Unit process data (S/F = steam to feed ratio).

7.2. Heavy Minerals Concentrate

The Coarse (HMC Production) circuit of CVW™ technology produces cleaned heavy minerals concentrate from the coarse sands fraction of froth treatment tailings. A flotation operation is used to concentrate the heavy minerals in the coarse sands fraction. This HMC is contaminated with bitumen and a solvent extraction circuit is utilized to recover the bitumen to produced the clean HMC, which is then transferred to the Minerals Separation Plant for upgrading to marketable products. At the Integrated Pilot, the Coarse circuit was operated in 2012-13 to produce bulk volumes of cleaned HMC for subsequent mineral separation processing validations.

The HMCP operations were run at CanmetENERGY's froth treatment pilot facility between August 2012 and February 2013, with HMC production occurring from October 2012 to January 2013. The primary goal of the HMC Production operation is to produce two tonnes of on-specification heavy minerals concentrate for use in the zircon production demonstration planned for latter half of 2013. This requires the continuous operation of the HMC Production module ('Coarse') process, for extended periods of time. Further, incremental operational performance improvements were sought, to enhance production and unit operations efficiencies, of the HMC production circuitry relative to its performance during the 2010-11 Integrated Demonstration Plant campaign. The efficiencies of individual unit operations comprising the HMCP plant were examined from the perspectives of produced heavy minerals and zircon, bitumen and diluent. The hydrocarbon performance has been described elsewhere; this section will focus on heavy mineral concentrate production.

Heavy minerals content and chemical compositions of sample streams was determined by a heavy liquid separation technique performed on the solids fraction saved from the Dean Stark Soxhlet extractions. These solids were split into two homogeneous sub-samples. One sub-sample (~100g) was shipped to the Materials Engineering Centre at Dalhousie University in Halifax, Nova Scotia while the other (~approximately 10 grams) was shipped to Ultratrace Pty in Australia. Materials Engineering Centre performed a heavy liquid separation test on the solids sample to determine the relative heavy minerals content. Heavy minerals were defined as the sink fraction of the sample in tetrabromoethane and characterized by a density greater than 2.95 g/cc. Ultratrace Pty determined the chemical composition of 15 oxides, including ZrO2 and TiO2, and radioactives content (uranium and thorium) using x-ray fluorescence.

The purpose of the bulk flotation circuit was to concentrate heavy minerals into a produced froth, thereby rejecting lighter minerals to the flotation tailings. The designed stream mass split for the circuit was 50% to the froth and the balance to tailings. Each of the coarse sands feed, produced froth and, for a period during operations, the flotation tailings were assayed for chemical composition and heavy minerals content every four hours of steady operation for material balancing purposes. These data, along with measured stream flow rates, were utilized to calculate the recovery of heavy minerals (i.e., those with specific gravity greater than 2.95) and zircon (from zircon dioxide concentrations) into the heavy minerals concentrate froth. Select results on bulk flotation minerals recovery achieved during the Integrated Pilot is shown in **Table 7-10**. Mineral oxides are determined by chemical analysis (x-ray fluorescence) and are indicative of zircon and titanium minerals contained in the coarse sands feed stock that was derived from froth treatment tailings in the Company's primary separation classification. The CVW™ Coarse flotation operation achieves up to 95% recovery of valuable minerals including the critical mineral zircon. As described in the main body text, the produce HMC was characterized by a heavy mineral concentration of about 55%, in which the total heavy mineral content of the produced solids was determined by a heavy liquid separation test.

Table 7-10. Bulk flotation stream and chemical analysis from the Coarse bulk flotation circuit of the Integrated Pilot. Solids content determined from Dean Stark Soxhlet extraction (Maxxam Analytics) and metal oxide content determined by x-ray fluorescence, reported as weight fraction of contained solids. Recovery calculations based on feed and tailings streams.

Sample		Rate			Solids			ZrO2			TiO2			Recovery	
date	time	Feed	HMC	Tailings	Feed	HMC	Tailings	Feed	HMC	Tailings	Feed	HMC	Tailings	ZrO2	TiO2
yyyymmdd	HH:MM	kg/min	kg/min	kg/min	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.
20121017	12:00	1.568	0.824	0.744	13.707	15.160	13.580	3.020	6.640	0.220	9.790	18.300	1.460	96.575	92.989
20121017	16:00	1.559	0.810	0.749	12.050	15.693	11.690	3.140	6.190	0.390	9.680	18.100	2.110	94.211	89.841
20121017	20:00	1.500	0.750	0.750	13.510	10.227	12.620	3.390	11.200	0.420	9.640	22.500	2.350	94.213	88.614
20121018	0:00	1.500	0.750	0.750	8.127	3.783		3.290	2.070		13.300	11.100		100.000	100.000
20121030	0:00	1.468	0.439	1.029	15.887	13.810	8.120	5.680	3.150	0.410	17.300	10.400	2.360	97.414	95.113
20121030	8:00	1.466	0.847	0.619	14.683	10.720	20.440	2.390	6.220	0.800	7.970	17.700	4.580	80.325	66.223
20121030	12:00	1.474	0.694	0.780	11.777	9.437	16.010	2.440	6.300	0.420	7.960	17.500	3.280	87.617	70.357
20121030	16:00	1.496	0.782	0.714	6.763	12.503	21.070	5.720	2.140	0.640	16.200	8.000	3.300	83.364	69.712
20121030	22:00	1.507	1.000	0.507	13.420	12.657	16.640	2.440	5.430	0.450	8.810	17.500	2.940	92.307	86.079
20121031	4:00	1.489	0.933	0.556	11.207	15.220	11.380	2.650	4.670	0.220	9.230	16.000	2.620	96.852	89.237
20121031	0:00	1.534	0.611	0.923	13.713	14.913	12.710	2.390	5.190	0.290	9.250	16.900	2.820	93.233	82.999
20121031	8:00	1.554	0.743	0.811	16.160	15.483	14.610	4.610	2.560	0.180	16.300	9.390	1.680	98.158	95.137
20121031	16:00	1.513	0.799	0.714	12.220	14.120	19.940	5.120	2.480	0.910	16.600	9.380	5.730	86.314	73.420
20121031	20:00	1.546	0.907	0.639	19.350	14.790	12.760	2.500	4.970	0.180	9.440	17.200	1.540	98.038	95.554
20121031	12:00	1.552	0.846	0.706	15.747	15.880	15.330	4.170	2.420	0.110	16.500	9.190	1.190	98.832	96.806
20121101	0:00	1.474	0.755	0.719	14.677	16.440	16.520	2.310	4.750	0.220	9.000	16.400	3.070	94.771	81.271
20121105	20:00	1.555	0.453	1.103	18.773	12.127	11.640	4.790	2.240	0.160	16.100	8.690	2.250	98.532	93.856
20121105	12:00	1.500	0.750	0.750	15.550	17.987	16.250	2.120	5.200	0.240	8.890	17.500	2.420	94.085	85.776
20121106	8:00	1.472	0.957	0.515	13.107	13.543	12.040	2.330	4.690	0.230	9.260	17.600	3.010	96.827	89.553
20121106	0:00	1.453	0.576	0.877	12.510	12.350	13.140	4.710	2.000	0.140	15.400	8.600	1.450	98.116	94.031
20121106	4:00	1.515	0.581	0.934	13.010	9.973	12.100	5.260	2.680	0.450	17.400	9.070	3.430	95.095	88.697
20121106	20:00	1.450	0.734	0.716	11.103	17.407	10.940	2.060	4.270	0.160	8.270	14.800	2.190	96.221	87.116
20121106	16:00	1.310	0.710	0.600	19.480	17.043	17.060	2.110	4.300	0.500	9.030	15.700	3.850	90.495	82.898
20121107	12:00	1.440	0.730	0.710	10.990	15.887	9.360	2.110	3.850	0.140	8.580	14.800	1.700	97.214	91.680
20121107	8:00	1.489	0.759	0.730	13.773	19.160	15.560	1.840	3.640	0.220	8.330	14.800	2.600	93.378	82.713
20121107	0:00	1.512	0.694	0.818	15.630	11.750	10.710	4.120	2.120	0.180	15.100	8.640	2.460	98.380	93.961
20121107	4:00	1.475	0.711	0.764	15.600	13.927	11.540	4.140	2.180	0.210	14.800	8.950	2.170	98.056	94.382
20121107	20:00	1.515	0.763	0.752	15.420	11.643	10.300	4.840	2.900	0.650	15.000	9.110	3.220	95.546	92.881
20121108	0:00	1.453	0.735	0.717	14.603	13.443	10.970	5.230	3.110	0.460	16.300	10.100	2.520	96.738	94.266
20121107	16:00	1.500	0.850	0.650	19.470	13.160	11.820	2.630	3.810	0.480	9.030	13.400	2.110	95.199	93.853
20121108	4:00	1.456	0.781	0.675	10.150	5.990	3.790	5.160	2.820	0.780	15.700	9.390	3.260	97.383	96.406
20121120	4:00	1.584	0.804	0.780	19.250	16.600	14.560	3.010	4.230	0.490	9.200	13.100	2.290	93.937	90.729
20121120	8:00	1.606	0.796	0.810	16.550	19.050	12.800	4.860	2.540	0.340	14.700	8.190	1.880	97.271	95.011
20121121	0:00	1.498	0.732	0.766	7.220	14.530	5.130	3.430	5.480	0.250	9.700	15.400	1.330	97.352	95.018
20121120	20:00	1.468	0.682	0.786	14.050	17.000	11.510	3.110	5.400	0.240	9.040	15.100	1.600	96.615	92.237
20121121	8:00	1.663	0.893	0.770	16.480	10.320	10.900	6.030	2.950	0.290	16.400	8.820	1.610	98.527	96.994
20121120	12:00	1.558	0.721	0.837	16.720	15.130	14.130	4.920	3.000	0.160	14.300	8.990	1.040	98.524	96.698
20121120	16:00	1.521	0.738	0.783	12.800	14.390	11.390	4.960	2.910	0.270	14.600	8.780	1.470	97.506	95.388
20121121	4:00	1.533	0.751	0.782	13.820	17.910	13.840	3.230	5.690	0.140	9.480	15.900	0.740	97.786	96.012
20121121	20:00	1.548	0.810	0.738	12.640	16.010	14.300	2.960	4.890	0.290	8.790	14.000	1.980	94.716	87.851
20121121	12:00	1.638	0.911	0.727	15.920	14.370	12.160	4.780	3.030	0.210	13.600	9.060	1.130	98.511	97.183
20121122	4:00	1.437	0.646	0.791	13.450	16.930	16.380	2.860	5.120	0.800	9.220	15.000	3.330	81.249	75.788
20121121	16:00	1.683	0.973	0.710	14.530	17.740	10.860	4.540	3.000	0.330	13.000	8.950	1.380	97.708	96.653
20121122		1.551	0.801	0.750	16.360	18.130	13.420	3.040	5.380	0.200	9.440	15.200	1.420	97.390	94.033
20121126	16:00	1.367	0.615	0.752	8.310	15.110	7.480	2.820	3.910	0.520	8.800	13.700	2.800	90.869	84.245
20121127	4:00	1.408	0.747	0.661	11.300	8.820	6.400	4.230	2.840	1.680	14.000	9.670	7.500	89.437	85.752
20121127	0:00	1.380	0.774	0.606	13.660	5.950	5.460	4.520	2.390	0.770	13.900	7.990	2.500	97.012	96.845
20121126	20:00	1.441	0.666	0.775	16.630	11.420	8.820	3.290	3.000	0.500	11.800	10.300	2.620	95.665	93.667
20121127	12:00	1.602	0.798	0.804	15.870	17.450	9.140	3.090	4.950	0.320	9.600	14.700	1.520	97.007	95.423
20121127	20:00	1.524	0.749	0.775	15.540	18.090	13.050	4.840	3.100	0.270	14.400	9.650	1.620	97.618	95.196
20121128	4:00	1.452	0.761	0.691	13.200	6.220	5.300	4.550	3.110	0.420	13.800	9.420	1.740	98.236	97.591
20121128	0:00	1.464	0.738	0.726	13.660	15.240	10.270	4.800	3.040	0.430	14.800	9.430	1.570	96.660	96.045
20121128	8:00	1.529	0.775	0.754	12.850	11.300	7.010	2.990	4.600	0.370	9.370	14.200	1.660	96.671	95.234
20121127	16:00	1.437	0.685	0.752	11.130	14.840	8.860	3.120	5.720	0.260	9.270	16.100	1.680	96.528	92.450
Average		**1.503**	**0.756**	**0.747**	**13.965**	**13.866**	**12.147**	**3.679**	**4.009**	**0.385**	**11.951**	**12.747**	**2.379**	**95.116**	**90.323**
St. Dev.		**0.069**	**0.109**	**0.104**	**2.903**	**3.506**	**3.769**	**1.162**	**1.657**	**0.268**	**3.182**	**3.753**	**1.171**	**4.338**	**7.679**

The mineralogy of the produced HMC, emanating from the coarse sands feed and translating into a concentrate by means of flotation, is critical to determining the value of further processing to isolate marketable heavy minerals. An assessment of the mineralogy is conducted by measuring the chemical composition of produced HMC using XRF. The valuable heavy minerals are characterized by zircon dioxide and titanium dioxide and were found to be rather consistent over the entire HMC production run. In this and subsequent analysis, zircon silicate ($ZrSiO_4$) values – representing the valuable zircon minerals – are reported. These are stoichiometrically calculated from the reported zircon dioxide values in the XRF measurements.

The zircon content in heavy minerals fraction of the HMC produced in the HMCP 2012-13 averaged **13.3% ± 3.7%** and that for titanium dioxide, a proxy for ilmenite, rutile and leucoxene concentrations, was **32.5% ± 9.0%**. The zircon values are corrected for $ZrSiO_4$ from measured zircon dioxide concentrations determined by x-ray fluorescence measurements. The plotted data represent measurements from batches ranging in size from about three kilograms, obtained during early operations, to 18 kilograms in the final two operating cycles comprised of the operating period from December 2012 to January 2013. The valuable heavy minerals concentrations in the HM fraction are approximately double those found in the produced HMC; this finding is consistent with the measured HM content of this product stream.

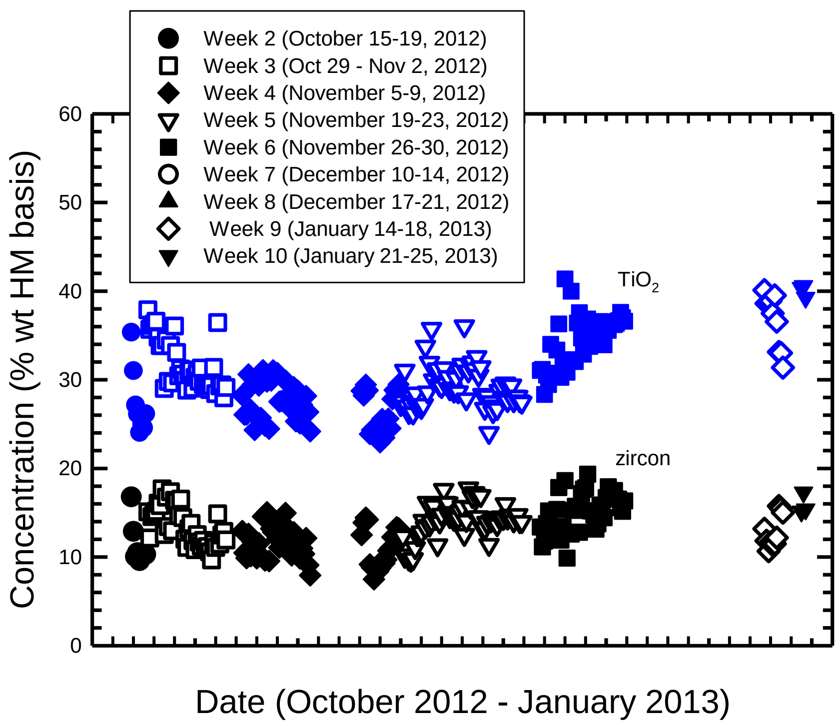

Figure 7-9. Zircon (black symbols) and titanium dioxide (blue symbols) concentrations in the heavy minerals fraction of concentrates produced during the HMCP 2012 operation, indicated by production week.

7.3. Critical Mineral Concentrates Production

Processing of the heavy minerals concentrate (HMC) produced in the CVW™ Concentrator Plant was achieved on a stage by stage basis, resulted in the development of mineral separation processes to make premium grade zircon and a HiTi concentrate in early testing (during the Integrated Pilot, 'Devon' and '738' test programs) and then zircon concentrates and higher recoveries of titanium concentrates in later studies ('Optimization').

All processing consisted of a Gravity Upgrade Process "GUP" to produce a critical mineral concentrate (CMC), which was subsequently processed in a Concentrate Upgrade Process "CUP" to produce a non-magnetic (N/M) concentrate, and a magnetic concentrate that, in Optimization studies, formed the primary feedstock for the titanium-enriched chloride ilmenite product. In early studies, the Primary Dry Circuit "N/M PDC" produced a non-conductor concentrate that was subsequently processed through a Wet Zircon Circuit ("WZC") and a non-magnetic finishing dry circuit (N/M FDC) to primarily make premium grade zircon and some zircon concentrate. In later studies, the CUP non-magnetic concentrate was immediately processed in a dry circuit (N/M FDC) to make a zircon concentrate product; in these works, pyrite was removed from the CMC prior to processing in the CUP. All wet processing was conducted with gravity spirals, flotation cells and wet magnets. All dry processing was conducted with high tension rolls and rare earth and/or induced magnets. Produced zircon products and overall recoveries derived from the process development test work is summarized in **Table 7-11** and zircon product qualities are given in **Figure 7-12**. Photographs of premium grade zircon products are shown in **Figure 7-10**. Particle size distributions of CVW™ heavy mineral concentrate and CVW™ mineral products are shown in **Figure 7-12**. Representative samples of x-ray fluorescence for elemental analysis and QEMScan for mineralogical analysis are presented in § 7.3.1 and § 7.3.2, respectively.

Table 7-11. Zircon recovery by processing circuit as per test program. Recoveries of ZrO_2 reported and determined by x-ray diffraction analysis; some confirmation by QEMScan mineralogy. Overall recovery is the product of that observed in each processing circuit. The Devon and 738 test programs produced a premium grade zircon product (ZrO_2 > 66%) and a zircon concentrate. Reported grades are based on zircon $ZrSiO_4$.

Zircon Concentrate Production – Recoveries (%wt)

	Test Program		
Processing Circuit	"Devon"	"738"	"Optimization"
GUP - CMC	93.7	94.1	96.3
Pyrite Removal	—	95.1	96.0
CUP – Non-Mag. Conc.	97.0	93.3	96.0
N/M PDC – Non-Conductor Conc.	90.3	96.0	—
WZC – Wet Zircon Conc.	96.1	90.5	—
N/M FDC – Primary/ Concentrate	84.7/6.35	79.1/7.7	0.0/98.5
Overall Recovery	66.8/5.0	57.4/5.6	87.4
Grade (Zircon, % wt)	99.5/93.3	99.5/94.4	74.6

The Optimized process differs from that of the Devon and 738 programs in that emphasis is placed on producing a concentrate rather than premium grade products. This is evident in the product grades, where the Optimization process produces a concentrate with about 75% zircon. Observed recovery is about 87% with respect to the HMC delivered from the Concentrator Plant.

Table 7-12. Zircon and zircon concentrate product qualities as per test program. Metal oxides and elemental values determined by x-ray diffraction analysis conducted by Bureau Veritas (formerly Ultratrace Pty). The 'Devon' and '738' test programs to produce premium grade zircon were executed during the Integrated Pilot and the 'Optimization' test work to produce zircon concentrates was executed in 2020-2021.

Zircon Production – Product Qualities

	Test Program		
Metal Oxide/Element	"Devon"	"738"	"Optimization"
TiO2	0.13/2.25	0.14	8.1
Fe2O3	0.07/0.36	0.08	1.2
SiO2	32.70/30.70	32.7	30.0
Al2O3	0.09/0.57	0.1	4.7
Cr2O3	0.00/0.01	0.0	0.0
ZrO2 +HfO2	66.3/62.20	66.3	49.7
P2O5	0.19/0.96	0.2	0.7
U + Th (ppmw)	459/1163	472	681
CeO2	0.03/0.15	0.03	0.3

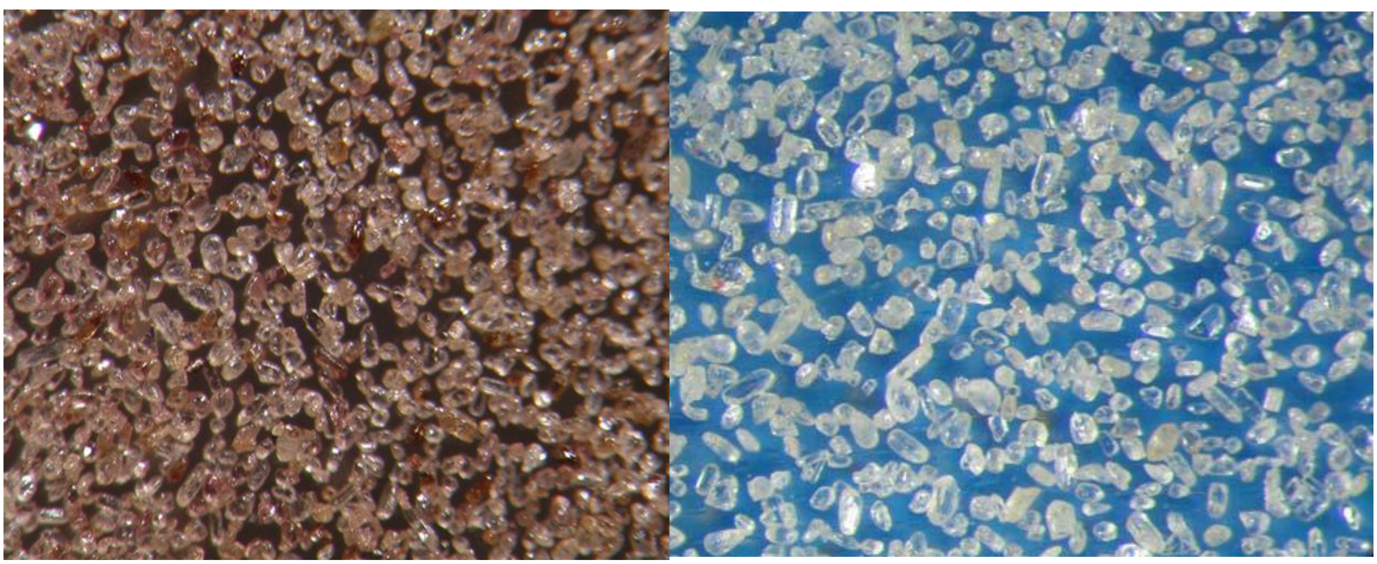

Figure 7-10. Micrographs of premium zircon produced during the 'Devon' test program (left), at 32x magnification under backfield reflective lighting, and '738' (right) test program.

In early test work, titanium-bearing mineral products were produced from PDC conductor fraction, after pyrite removal, in a Magnetic Dry Circuit (Mag. DC) comprised of high tension rolls and rare earth magnets. In the Optimization testing, titanium-bearing minerals were produced from the magnetic concentrate of the CUP and scavenged as conductors the non-magnetic dry circuit. Produced titanium-bearing mineral products and overall recoveries derived from the process development test work is summarized in **Table 7-13** and product qualities are given in **Table 7-14**. Exemplary output of analytical testing during the Optimization studies are collated in § 7.3.1 and §5.3.2, respectively.

Table 7-13. Titanium minerals recoveries by processing circuit as per test program. Recoveries of minerals reported and determined by QEMScan mineralogical analysis except for the Devon program, which reports on a TiO_2 basis. Overall recovery is the product of that observed in each processing circuit. The Devon test programs produced a HiTi product (TiO_2 > 66%) and an ilmenite concentrate. Reported grades are based on TiO_2 and QEMScan bases.

Titanium Production – Recoveries (% wt)

		Test Program						
Processing Circuit		Devon	"738"			"Optimization"		
		TiO2	Ilmenite	Leucoxene	Rutile	Ilmenite	**Leucoxene**	**Rutile**
GUP - HMC		50.7	81.2	65.5	62.8	93.1	83.3	78.4
Pyrite Removal		88.9	92.0	94.4	93.3	95.0	95.0	95.0
CUP – N/M Conc.		62.6	18.9	41.1	62.4	10.0	35.0	77.5
CUP – Mag. Conc.		-	-	-	-	90.0	55.0	5.0
N/M PDC– Cond.		87.54	89.9	53.1	69.9	97.0	92.0	87.0
Mag. PDC – Leu/Ilm		46.0/43.8	14.2	78.4	88.9	96.5	90	50.0
Overall Recovery	Minerals		1.8	10.6	22.7	85.4	**64.7**	**52.1**
	TiO2	11.2/10.7		11.1		55.3		
Grade	Minerals		20.5	41.4	20.5	50.9	37.5	6.5
	TiO2	89.5/63.8		90.2		72.0		

The Company has endeavoured to produce a titanium minerals since its inception and have developed several processing schemes to achieve saleable titanium mineral products. At the Integrated Pilot, CVW CleanTech advanced its Devon flowsheet, which produced two grades of titanium minerals – a HiTi product that resembles leucoxene (TiO_2 > 75%) and an ilmenite product (TiO_2 > 60%) with a balanced net recovery of about 21% from HMC into a blended product of 77.0% TiO_2. The '738' program indicated about 11% recovery into a titanium mineral product with 90% TiO_2 content. The low recoveries observed in during the Integrated Pilot are a result of the focus on processing a conductor fraction of the non-magnetic dry circuit.

In the Optimization program, titanium minerals were produced from the magnetic stream of the upstream CUP with some scavenging through the downstream zircon circuitry emanating from the CUP non-magnetic stream. The Optimization flow sheet resulted in significantly greater titanium minerals recoveries at 85.4%, 64.7% and 52.1% for ilmenite, leucoxene and rutile respectively, with an overall TiO_2 recovery of about 55% into a chloride ilmenite product that is characterized by 72% TiO_2. The mineralogy of the chloride ilmenite product consists of about 51% ilmenite, 37.5% leucoxene and 6.5% rutile.

Table 7-14. Qualities of titanium-bearing mineral products as per test program. Metal oxides and elemental values determined by x-ray diffraction analysis conducted by Bureau Veritas (formerly Ultratrace Pty). The 'Devon' and '738' test programs to produce higher grade 'HiTi' products were executed during the Integrated Pilot and the 'Optimization' test work to produce chloride ilmenite concentrates ($TiO_2 \geq 72\%$) was executed in 2020-2021.

Titanium Production – Product Qualities

	Test Program		
Metal Oxide/Element	"Devon"	"738"	"Optimization"
TiO2	89.47/63.80	90.20	72.0
Fe2O3	1.05/28.63	3.10	17.7
SiO2	5.51/1.30	3.50	3.1
Al2O3	1.13/1.07	1.00	1.1
Cr2O3	0.10/1.30	0.19	0.7
ZrO2 +HfO2	1.13/0.16	0.18	1.2
P2O5	0.10/0.21	0.06	0.2
U + Th (ppmw)	116/58	113	110
CeO2	0.03/0.02	0.01	0.02

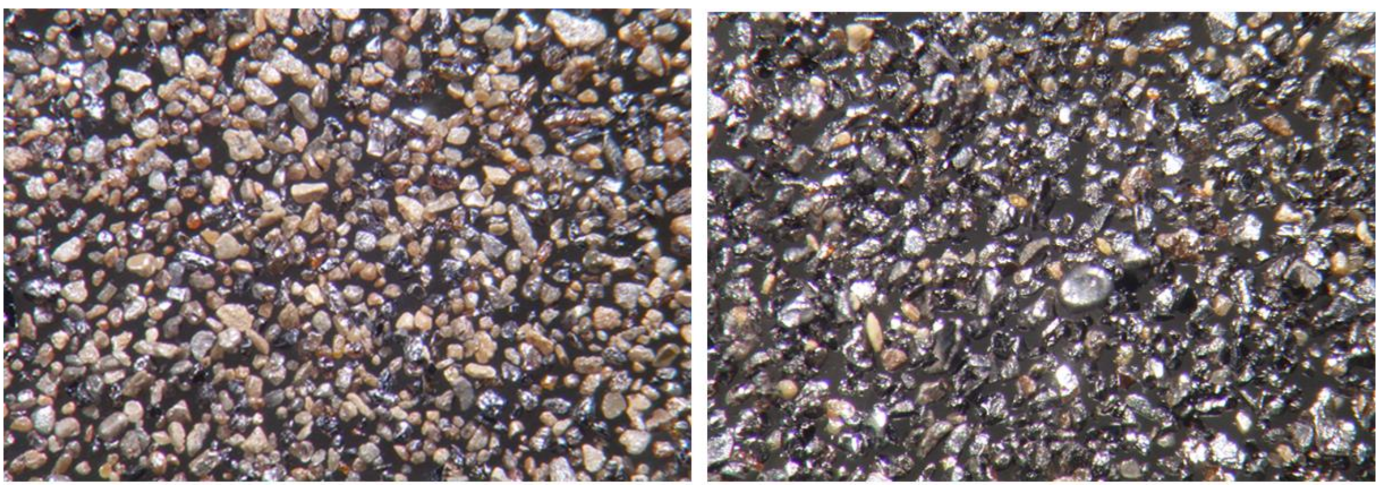

Figure 7-11. Micrograph of leucoxene (left; 89.5% TiO_2) and secondary ilmenite (right; 63.8% TiO_2) produced from conductor feed in the 'Devon' test program at the Integrated Pilot; under 20 times and 32 times magnification, respectively, and backfield reflective lighting.

The Athabasca oil sands froth treatment tailings and resultant CVW™ coarse sands fraction are rather fine with respect to particle sizing, in which the HMC produced at the Integrated Pilot (and utilized for mineral process development works) is characterized by a d_{50} of about 105 microns. A particle size distribution via nested sieving was conducted on the resultant CVW™ mineral products to evaluate the product grain sizing (**Figure 7-12**), where it can be seen that the d_{50} of premium grade zircon ranges from just less than 60µm ('Devon") to about 65 microns ('738'). The d_{50} of zircon concentrate is about 65 microns and that of the chloride ilmenite product is about 85µm.

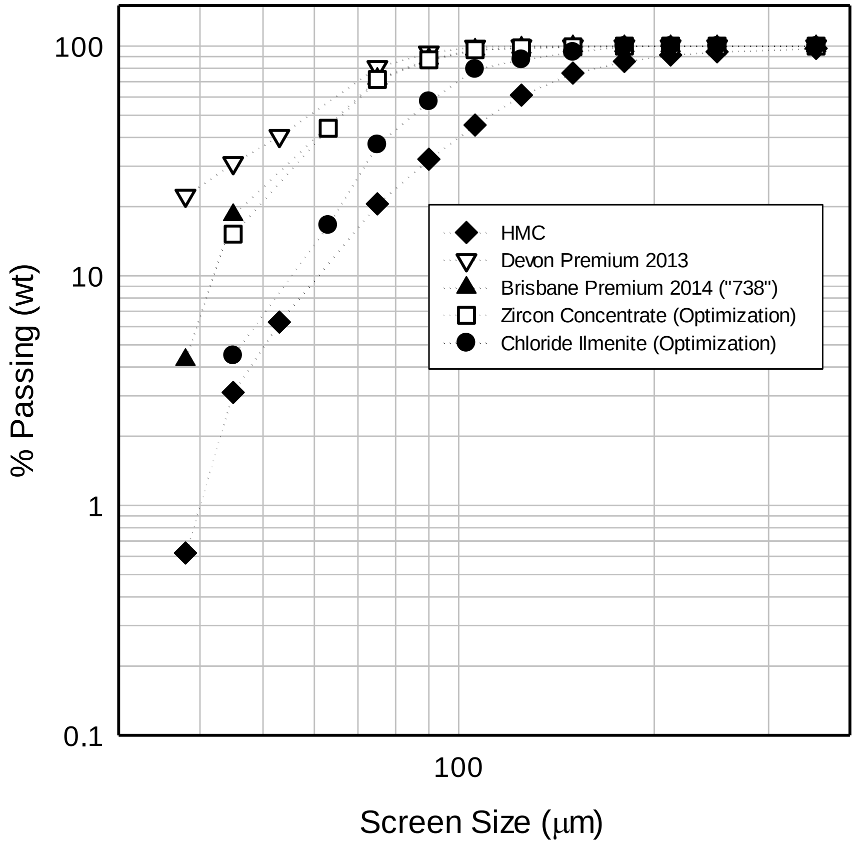

Figure 7-12. Particle size distributions of Integrated Pilot HMC, premium grade zircon from the "Devon" and '738' tests and zircon concentrate and chloride ilmenite from the Optimization testing in 2021.

7.3.1. X-Ray Flouresence Analytical Report ('1845' test program)

Bureau Veritas Minerals Pty Ltd
MINERAL TESTING & LABORATORY SERVICES
ABN: 30 008 127 802
58 Sorbonne Crescent Canning Vale
Perth WA 6155 Australia
Telephone (08) 9456 0404
Facsimile (08) 9456 0403

Reference: **u309435**
Date Finished: 04/03/2020
Order: 00008693
Project: 1845
Date Received: 27/02/2020
Samples Analysed: **24**

FINAL ANALYSIS REPORT

Analysis of Mineral Samples

for

IHC Robbins

PO Box 1401 Oxley QLD 4075

Attention: Mr A Kruger

Authorised By:

Tom Lowther
Operations Manager
Bureau Veritas Minerals Pty Ltd

Bureau Veritas Minerals Pty Ltd
MINERAL TESTING & LABORATORY SERVICES

ABN: 30 008 127 802
58 Sorbonne Crescent Canning Vale
Perth WA 6155 Australia
Telephone (08) 9456 0404
Facsimile (08) 9456 0403

Reference: u309435 **Order Number:** 00008693

	TiO2 %	Fe2O3 %	Fe2O3 (calc) %	FeO %
Detection Limit	0.01	0.01	0.01	0.1
1845 T101 N/C	5.10	1.98	1.21	0.69
1845 T102 MID+N/C	11.3	3.30	1.04	2.03
1845 T103 COND	79.1	12.9	9.44	3.11
1845 T103 N/C	36.2	2.14	1.15	0.89
1845 T104 COND	82.8	8.88	6.58	2.07
1845 T104 COND Rpt	82.8	8.89	6.72	1.95
1845 T104 N/C	52.5	2.59	1.58	0.91
1845 T104 MID	79.1	4.79	2.90	1.70
1845 T105 MAG	27.4	8.52	4.87	3.28
1845 T105 N/M	19.5	0.32	0.10	0.20
1845 T111 MID+N/C	8.43	23.3	7.30	14.4
Std Nominal	44.5	52.5		1.57
Determined	44.5	52.4	NR	1.53
1845 T112 OS	6.88	43.0	11.8	28.1
1845 T113 COND+M2	61.7	30.2	19.1	10.0
1845 T113 N/C	33.3	34.7	13.5	19.1
1845 T114 COND	61.1	27.2	18.0	8.28
1845 T114 MID+N/C	37.9	31.9	13.2	16.8
1845 T301 N/C	6.34	7.21	3.45	3.38
1845 T302 N/C+M3	14.3	14.9	4.02	9.79
1845 T303 N/C	57.6	10.9	4.64	5.63
1845 T303 COND+M2	68.8	22.6	14.0	7.76
1845 T304 N/C+M3	71.8	10.0	6.13	3.48
1845 T305 COND+M2	72.6	17.1	11.7	4.90
1845 T305 MAG	20.6	15.1	8.72	5.74
1845 T305 N/M	23.7	0.45	0.28	0.15
1845 HMC	32.6	11.1	4.74	5.72
1845 HMC Rpt	32.5	11.1	4.77	5.70
Std Nominal				28.4
Determined	22.3	26.4	NR	28.3
Std Nominal	0.62	3.23		1.57
Determined	0.63	3.22	NR	NR
Std Nominal	3.07	46.1		28.4
Determined	3.04	46.1	NR	NR

****

Bureau Veritas Minerals Pty Ltd
MINERAL TESTING & LABORATORY SERVICES

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58 Sorbonne Crescent Canning Vale
Perth WA 6155 Australia
Telephone (08) 9456 0404
Facsimile (08) 9456 0403

Reference: u309435 Order Number: 00008693

	SiO2 %	Al2O3 %	Cr2O3 %	MgO %
Detection Limit	0.01	0.01	0.001	0.01
1845 T101 N/C	31.0	4.98	0.022	0.59
1845 T102 MID+N/C	28.6	4.37	0.044	0.49
1845 T103 COND	1.97	0.92	0.516	0.22
1845 T103 N/C	20.7	1.24	0.106	0.10
1845 T104 COND	2.59	1.06	0.490	0.17
1845 T104 COND Rpt	2.56	1.06	0.495	0.17
1845 T104 N/C	15.8	1.43	0.136	0.10
1845 T104 MID	6.79	1.71	0.320	0.18
1845 T105 MAG	21.9	12.0	0.258	1.64
1845 T105 N/M	26.8	1.12	0.022	0.05
1845 T111 MID+N/C	26.6	20.1	0.111	3.23
Std Nominal	2.23	0.73	0.114	0.74
Determined	2.22	0.74	0.114	0.73
1845 T112 OS	19.0	9.91	0.050	2.97
1845 T113 COND+M2	1.13	0.94	1.007	0.62
1845 T113 N/C	7.25	3.92	0.697	0.92
1845 T114 COND	1.98	1.56	1.524	0.63
1845 T114 MID+N/C	8.76	4.68	0.637	1.20
1845 T301 N/C	39.6	13.3	0.035	1.90
1845 T302 N/C+M3	29.0	13.3	0.059	1.70
1845 T303 N/C	13.1	3.15	0.286	0.38
1845 T303 COND+M2	1.75	1.00	0.660	0.42
1845 T304 N/C+M3	7.97	2.41	0.472	0.29
1845 T305 COND+M2	2.94	1.39	0.676	0.32
1845 T305 MAG	26.1	18.0	0.241	2.76
1845 T305 N/M	37.6	2.79	0.026	0.14
1845 HMC	25.9	9.18	0.237	1.34
1845 HMC Rpt	25.8	9.18	0.237	1.32
Std Nominal				
Determined	17.5	0.82	0.064	0.39
Std Nominal	69.4	14.1	0.008	0.96
Determined	69.4	14.1	0.007	0.97
Std Nominal	31.5		0.087	1.71
Determined	31.4	11.7	0.091	1.75

****

BUREAU VERITAS
Bureau Veritas Minerals Pty Ltd
MINERAL TESTING & LABORATORY SERVICES
ABN: 30 008 127 802
58 Sorbonne Crescent Canning Vale
Perth WA 6155 Australia
Telephone (08) 9458 0404
Facsimile (08) 9458 0403

Reference: u309435 **Order Number:** 00008693

	MnO %	ZrO2 %	P2O5 %	U XRF ppm
Detection Limit	0.01	0.01	0.001	10
1845 T101 N/C	0.05	51.47	0.741	373
1845 T102 MID+N/C	0.08	47.91	0.535	333
1845 T103 COND	0.36	0.23	0.162	22
1845 T103 N/C	0.05	34.05	0.665	357
1845 T104 COND	0.25	0.19	0.168	25
1845 T104 COND Rpt	0.25	0.20	0.166	13
1845 T104 N/C	0.06	22.09	0.564	245
1845 T104 MID	0.12	3.04	0.257	62
1845 T105 MAG	0.25	18.81	1.23	192
1845 T105 N/M	<0.01	48.72	0.400	322
1845 T111 MID+N/C	0.96	5.04	0.563	59
Std Nominal	1.19	0.12	0.030	<10
Determined	1.19	0.12	0.028	<10
1845 T112 OS	2.17	0.33	0.356	<10
1845 T113 COND+M2	1.06	0.14	0.218	<10
1845 T113 N/C	1.17	1.52	0.451	26
1845 T114 COND	1.01	0.15	0.251	17
1845 T114 MID+N/C	1.29	0.67	0.367	22
1845 T301 N/C	0.24	23.61	0.641	179
1845 T302 N/C+M3	0.50	18.66	0.551	131
1845 T303 N/C	0.33	6.20	0.542	83
1845 T303 COND+M2	0.75	0.16	0.236	10
1845 T304 N/C+M3	0.35	1.19	0.426	36
1845 T305 COND+M2	0.58	0.16	0.299	28
1845 T305 MAG	0.50	5.58	0.606	75
1845 T305 N/M	0.01	31.42	0.549	224
1845 HMC	0.37	12.30	0.498	81
1845 HMC Rpt	0.37	12.36	0.492	89
Std Nominal			0.081	155
Determined	0.61	32.19	0.074	153
Std Nominal	0.02		0.389	1140
Determined	0.02	0.02	0.391	1110
Std Nominal	0.08	0.08	0.850	<10
Determined	0.09	0.08	0.845	<10

****

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Reference: u309435 **Order Number:** 00008693

	Th XRF ppm	V2O5 %	Nb2O5 %	SO3 %
Detection Limit	10	0.01	0.001	0.01
1845 T101 N/C	315	0.02	0.033	0.15
1845 T102 MID+N/C	318	0.03	0.048	0.23
1845 T103 COND	45	0.25	0.309	2.67
1845 T103 N/C	337	0.08	0.117	0.40
1845 T104 COND	63	0.25	0.313	1.54
1845 T104 COND Rpt	66	0.26	0.308	1.55
1845 T104 N/C	213	0.13	0.161	0.49
1845 T104 MID	123	0.21	0.261	0.80
1845 T105 MAG	475	0.10	0.099	0.53
1845 T105 N/M	257	0.04	0.074	0.18
1845 T111 MID+N/C	163	0.05	0.021	0.41
Std Nominal	11	0.24	0.087	0.03
Determined	14	0.23	0.087	0.02
1845 T112 OS	38	0.05	0.011	0.98
1845 T113 COND+M2	33	0.22	0.118	0.20
1845 T113 N/C	83	0.11	0.084	1.72
1845 T114 COND	11	0.21	0.124	0.33
1845 T114 MID+N/C	52	0.13	0.085	1.26
1845 T301 N/C	201	0.03	0.025	0.19
1845 T302 N/C+M3	166	0.05	0.046	0.46
1845 T303 N/C	113	0.14	0.166	0.64
1845 T303 COND+M2	54	0.24	0.186	1.00
1845 T304 N/C+M3	85	0.19	0.202	0.55
1845 T305 COND+M2	69	0.24	0.196	0.57
1845 T305 MAG	165	0.09	0.051	0.36
1845 T305 N/M	182	0.05	0.072	0.21
1845 HMC	124	0.11	0.096	0.48
1845 HMC Rpt	127	0.11	0.097	0.49
Std Nominal	81	0.12		
Determined	86	0.11	0.046	<0.01
Std Nominal	644		0.008	
Determined	646	0.01	0.007	0.09
Std Nominal	233	0.07	0.185	0.13
Determined	234	0.07	0.185	0.11

****

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Reference: u309435 **Order Number:** 00008693

	CaO	K2O	CeO2	LOI1000
	%	%	%	%
Detection Limit	0.01	0.001	0.002	0.01
1845 T101 N/C	0.38	0.034	0.328	1.16
1845 T102 MID+N/C	0.31	0.042	0.158	0.91
1845 T103 COND	0.11	0.078	<0.002	2.25
1845 T103 N/C	0.33	0.109	0.120	1.83
1845 T104 COND	0.12	0.103	0.014	1.90
1845 T104 COND Rpt	0.12	0.105	0.016	1.93
1845 T104 N/C	0.29	0.145	0.078	1.88
1845 T104 MID	0.17	0.159	0.034	1.68
1845 T105 MAG	0.54	0.072	0.844	2.23
1845 T105 N/M	0.25	0.059	0.030	0.84
1845 T111 MID+N/C	1.33	0.069	0.310	6.35
Std Nominal	0.22	0.045	0.004	
Determined	0.22	0.046	0.004	-2.99
1845 T112 OS	2.08	0.067	0.020	12.62
1845 T113 COND+M2	0.19	0.032	0.002	1.63
1845 T113 N/C	1.47	0.099	0.074	12.82
1845 T114 COND	0.30	0.050	0.008	3.01
1845 T114 MID+N/C	1.23	0.091	0.044	10.00
1845 T301 N/C	0.81	0.088	0.234	2.48
1845 T302 N/C+M3	0.90	0.076	0.140	4.19
1845 T303 N/C	0.57	0.173	0.094	4.59
1845 T303 COND+M2	0.17	0.056	0.010	1.91
1845 T304 N/C+M3	0.33	0.160	0.050	3.11
1845 T305 COND+M2	0.19	0.087	0.016	2.07
1845 T305 MAG	0.88	0.083	0.318	4.12
1845 T305 N/M	0.49	0.129	0.040	1.14
1845 HMC	0.60	0.103	0.136	2.69
1845 HMC Rpt	0.61	0.103	0.140	2.75
Std Nominal		0.050		1.34
Determined	0.17	0.049	0.006	1.36
Std Nominal	1.46	1.91	0.016	5.67
Determined	1.45	1.91	0.016	5.78
Std Nominal	1.76	0.285	0.438	10.30
Determined	1.81	0.284	0.438	10.30

****

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Reference: u309435 **Order Number:** 00008693

****

These results pertain to the samples as received at this laboratory.
Where standards are reported, the nominal value for the element is reported above the result found.

"NR" Implies result is not required for this determination

Sample Storage

****

The excess material (Residue) will be dumped after 30 days

The pulp samples (Pulp) will be dumped after 60 days as per instructions.

Sample Preparation

****

The samples have been sorted and dried. The whole sample has been pulverised in a vibrating pulveriser equipped with a Tungsten Carbide bowl. A barren flush has been pulverised between each sample.

Digest and Analysis:

****

The samples have been cast using a 12:22 flux to form a glass bead which has been analysed by XRF.

Al2O3,CaO,CeO2,Cr2O3,Fe2O3,K2O,MgO,MnO,Nb2O5,P2O5,SiO2,SO3,Th,XRF,TiO2,U,XRF,V2O5,ZrO2
have been determined by X-Ray Fluorescence Spectrometry on oven dry (105'C) sample unless otherwise stated.

Loss on Ignition has been determined between 105 and 1000 degrees celsius. Results are reported on a dry sample basis.

LOI1000
have been determined Gravimetrically.

A sub-sample has been digested with Sulphuric and Hydrofluoric acids.

FeO
have been determined volumetrically.

Fe2O3(calc)
have been calculated from other components assayed.

7.3.2. QEMScan Analysis ('1845' Test Program)

Mineralogical Report
N9151QS20

IHC Robbins

Mineralogy of 8 samples

7 April 2020

Reported by: Roger Anderson

Reviewed by: Barry Whittington

BUREAU VERITAS

BUREAU VERITAS MINERALS PTY LTD
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Summary

On the 19th of March 2020, IHC Robbins submitted 8 HMS samples for Assay and QEMSCAN analyses. The samples were submitted for elemental assay to BV Mineral Chemistry in Cardiff, NSW.

Data validation shows a good correlation between the QEMSCAN generated assays and chemical assays. The mineral abundance varies between the samples. The Summary table and mineralogy overviews below have been provided to highlight information that may be of interest to the client.

Please refer to the individual tabs for detailed information on; Mineral Abundance, Elemental Deportment, Size Distribution, Liberation and Locking.

Summary		NM conc mag	NM conc NM	Ilmenite Prod	HITI Prod	Rejects	300 Conc	300 Mag	300 Cond P
	Particle Size Est P80	93	82	131	133	114	97	118	152
TiO2 Minerals (excl. intergrowths)	Mineral Mass (%)	33.5	19.5	90.3	89.0	11.2	25.8	29.1	92.4
	Mineral Size Est P80	88	73	108	107	67	84	92	144
	Mineral Liberated (%)	84	70	87	81	47	64	88	92
Zircon	Mineral Mass (%)	28.8	72.0	0.1	0.2	6.8	53.8	8.8	0.1
	Mineral Size Est P80	78	78	49	116	76	85	74	58
	Mineral Liberated (%)	94	98	74	74	91	97	95	88
REE Combined	Mineral Mass (%)	4.4	0.7	0.0	0.1	1.5	0.9	1.8	0.3
	Mineral Size Est P80	68	35	65	149	63	98	77	90
	Mineral Liberated (%)	58	14	24	90	59	62	68	77

CLIENT DETAILS

Company	IHC Robbins
Address	PO Box 1401 OXLEY QLD 4075
Contact	Arno Kruger
Email	a.kruger@ihcrobbins.com

INTRODUCTION

On the 19th of March 2020, IHC Robbins submitted 8 HMS samples for Assay and QEMSCAN analyses. The samples were submitted for elemental assay to BV Mineral Chemistry in Cardiff, NSW. The sample details and analyses are listed in the table below.

SAMPLE LIST / ANALYSES

Sample Description	BV IDs	Assay	QEMSCAN	
			No. Blocks prepared	Analysis
NM conc mag HM	NM conc mag	1	1	PMA
NM conc NM HM	NM conc NM	1	1	PMA
Ilmenite Prod HM	Ilmenite Prod	1	1	PMA
HiTi Prod HM	HiTi Prod	1	1	PMA
Rejects HM	Rejects	1	1	PMA
300 NMConc HM	300 Conc	1	1	PMA
300 Mag conc HM	300 Mag	1	1	PMA
300 Cond Product HM	300 Cond P	1	1	PMA
TOTAL		8	8	

Note: Non-hazardous samples will be automatically disposed of after 3 months; hazardous samples will be automatically returned to the client, at the clients expense, after 3 months, unless otherwise advised by the client.

SAMPLE PREPARATION / ANALYSIS

A sub sample was taken from the provided samples. Graphite was added to the sub sample to aid in separation of the individual particles. The sub sample/graphite mixture was then mounted in an epoxy resin to form a block. The block was ground, polished and coated with carbon prior to QEMSCAN analysis. The PMA method was used on the samples and the general HMS v3.2 SIP used to classify the data. The data were processed using iDiscover v.5.3. Field Stitching, Particulator, Area>5 filter, Touching Particles and Boundary Phase processors were applied. Please note the sample was run at a 10µm pixel spacing.

INDEMNITY STATEMENT

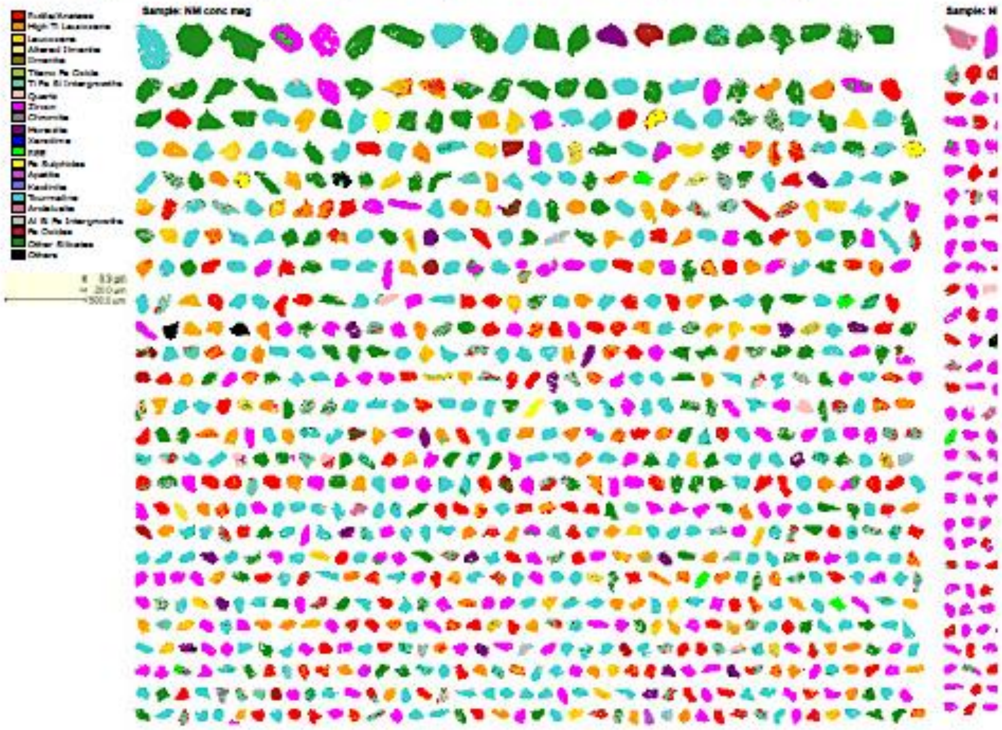
This report has been prepared for the client by Bureau Veritas Minerals Pty Ltd. Other parties, at the discretion of the client may be given access to the report or receive copies of the report.

While Bureau Veritas Minerals Pty Ltd has taken all reasonable care to ensure that the facts and opinions expressed in this report are accurate it does not accept any legal responsibility for any loss or damage suffered resulting from use of this report howsoever caused and whether by breach of contract, negligence or otherwise.

The results presented in this report pertain only to the sample received for testing.

GEMSCAN IMAGES

Particles are sorted by Area. Please note some smaples appear to have a high amount of touching particles. All efforts are made to reduce touching particles however some are still present.



MINERAL ABUNDANCE

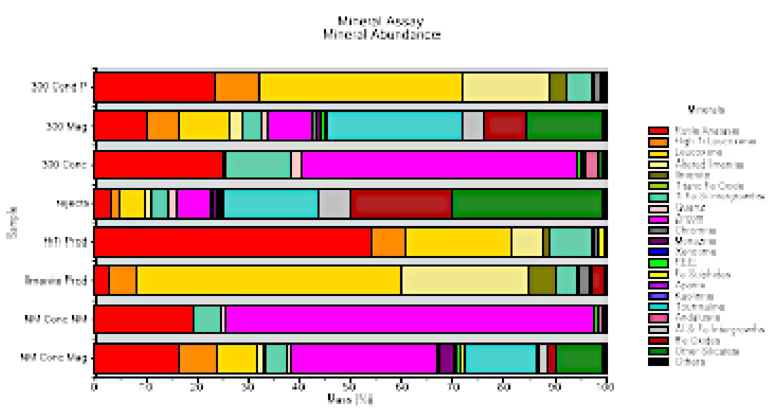
The mineral abundance data for each analysed sample is listed in the below table and shown graphically.

Note: QEMSCAN assigns each pixel a mineral 'identity' on the basis of the QEMSCAN-generated assays. As such, QEMSCAN cannot differentiate between polymorphs (e.g. pyrite/marcasite, hematite/maghemite). Mineral phases may be miss-assigned if there is significant overlap in the mineral composition. In addition, phases will not be assigned a mineral identity if there is no corresponding QEMSCAN assay in the SIP database.

Mineral Abundance - Main Mineral List

	Sample	NM conc mag	NM conc NM	Ilmenite Prod	HiTi Prod	Rejects	300 Conc	300 Mag	300 Cond P
Mineral Mass (%)	Rutile/Anatase	16.6	19.2	2.9	54.1	3.1	25.0	10.3	23.5
	High Ti Leucoxene	7.3	0.3	5.3	6.9	1.7	0.7	6.3	8.8
	Leucoxene	8.0	0.0	51.8	20.6	5.2	0.0	9.9	30.5
	Altered Ilmenite	1.3	0.0	24.9	6.1	1.0	0.0	2.2	18.9
	Ilmenite	0.2	0.0	5.3	1.2	0.2	0.0	0.3	3.5
	Titano Fe Oxide	0.0	0.0	0.2	0.1	0.1	0.0	0.1	0.1
	Ti Fe Si Intergrowths	4.2	5.4	4.2	8.1	3.3	12.5	3.5	4.9
	Quartz	0.7	0.6	0.3	0.4	1.5	2.2	1.4	0.4
	Zircon	28.6	72.0	0.1	0.2	6.8	53.8	8.8	0.1
	Chromite	0.4	0.0	2.2	0.8	0.2	0.0	0.5	1.1
	Monazite	3.1	0.0	0.0	0.0	1.0	0.0	1.0	0.0
	Xenotime	0.1	0.0	0.0	0.0	0.2	0.0	0.1	0.0
	REE	1.2	0.7	0.0	0.1	0.4	0.9	0.8	0.3
	Fe Sulphides	0.5	0.1	0.1	1.0	0.5	0.1	0.3	0.1
	Apatite	0.1	0.1	0.0	0.0	0.1	0.5	0.2	0.0
	Kaolinite	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0
	Tourmaline	14.1	0.0	0.1	0.0	18.4	0.1	26.2	0.0
	Andalusite	0.2	0.8	0.0	0.0	0.1	2.6	0.2	0.0
	Al Si Fe Intergrowths	2.0	0.0	0.0	0.0	6.5	0.0	4.3	0.0
	Fe Oxides	1.3	0.0	2.8	0.2	19.7	0.0	8.3	0.5
	Other Silicates	9.4	0.4	0.2	0.1	29.4	0.8	14.9	0.1
	Others	0.5	0.3	0.0	0.1	0.8	0.8	0.5	0.1
	TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Mineral Abundance Graph - Main Mineral List



Mineral Abundance - Expanded TiO2 Mineral List

	Sample	NM conc mag	NM conc NM	Ilmenite Prod	HiTi Prod	Rejects	300 Conc	300 Mag	300 Cond P
(%)	Rutile/Anatase	16.6	19.2	2.9	54.1	3.1	25.0	10.3	23.5
	TiO2 98%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TiO2 95%	0.9	0.2	0.2	0.6	0.2	0.6	0.9	0.8
	TiO2 90%	3.6	0.1	1.8	3.1	0.7	0.2	3.1	3.9
	TiO2 85%	2.7	0.0	3.3	3.2	0.8	0.0	2.3	4.2
	TiO2 80%	2.6	0.0	6.8	4.6	1.3	0.0	2.7	7.6
	TiO2 75%	2.9	0.0	19.7	7.9	2.1	0.0	3.9	14.9
	TiO2 70%	2.6	0.0	23.3	8.2	1.6	0.0	3.4	17.1
	TiO2 65%	0.9	0.0	13.4	3.8	0.7	0.0	1.4	9.5
	TiO2 60%	0.2	0.0	5.9	1.2	0.2	0.0	0.4	3.9
	TiO2 55%	0.2	0.0	5.5	1.0	0.1	0.0	0.3	3.5
	TiO2 50%	0.1	0.0	4.3	0.9	0.1	0.0	0.2	2.8
	TiO2 45%	0.0	0.0	0.8	0.2	0.0	0.0	0.0	0.6
	TiO2 40%	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.1
	TiO2 30%	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.1

ELEMENTAL DEPORTMENT

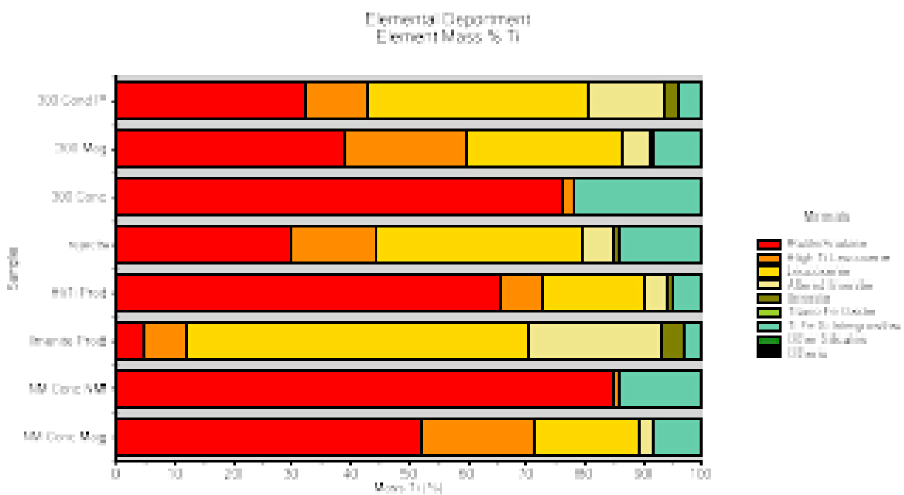
Elemental deportment is the distribution of the element of interest against the minerals list. Only minerals that contain the element of interest are reported. The provided data is a normalisation of the QEMSCAN assay data. The elemental deportment data are presented for: (i) Titanium and (ii) Iron. Please note elements that have a concentration of less than 1wt% the associated data should be treated as indicative only.

Elemental deportment is calculated using pixel elemental information. Each pixel analysed is assigned a chemistry and an elemental deportment is determined using this information. Due to the nature of the data collection device (i.e. SEM), some mixed spectra occur along mineral boundaries due to X-rays being excited from both minerals. Boundary phase entries have been designed to account for this, with a combined chemistry often assigned to these boundary phases. These entries are typically assigned to the major mineral group, with which it is a mixed phase. As such, minor elements may be reported in phases which do not contain that element (e.g. Fe in quartz). Please note minerals or mineral groups that have a mineral abundance of less than 0.5wt% the associated data should be treated as indicative only.

Titanium Deportment

Sample		NM conc mag	NM conc NM	Ilmenite Prod	HiTi Prod	Rejects	300 Conc	300 Mag	300 Cond P
Mass %	Rutile/Anatase	51.9	84.8	4.7	65.5	30.1	76.1	39.2	32.4
	High Ti Leucoxene	19.5	1.1	7.2	7.1	14.2	2.0	20.8	10.4
	Leucoxene	17.7	0.0	58.4	17.4	35.2	0.1	26.6	37.8
	Altered Ilmenite	2.4	0.0	22.9	4.2	5.6	0.0	4.7	13.2
	Ilmenite	0.3	0.0	3.9	0.6	0.7	0.0	0.5	2.2
	Titano Fe Oxide	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
	Ti Fe Si Intergrowths	8.2	14.0	2.9	5.1	14.2	21.8	8.2	4.1
	Other Silicates	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Others	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ti Assay		16.2	11.7	36.7	47.3	5.6	17.3	12.2	42.2

Titanium Deportment Graph



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