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Closing the loop on iron ore tailings: a case study on value recovery, water reticulation and tailings storage facility footprint

Nicolene Roux [a,b,*], Phildré F Lötter [a]

[a] *NXTGEN, Fraser Alexander (Pty) Ltd, South Africa*

[b] *Department of Engineering and Technology Management, University of Pretoria, South Africa*

Abstract

Iron ore is a bulk commodity and a major contributor to tailings. Historically, mine owners could prioritise the recovery of high-grade material leading to the deposition of tailings that can now be considered as economically recoverable. This case study examines such an opportunity at a mine in an arid region of South Africa that adopted an environmental, social and governance (ESG)-driven approach to tailings. In addition to pursuing value recovery during tailings reprocessing, alternative water recovery options were tested to assess the feasibility of transitioning to a water-efficient tailings storage facility. Laboratory and pilot-scale test work evaluated several dewatering options with pressure filtration appearing most promising yet ultimately delivering questionable benefits. The potential ESG gains from tailings reprocessing were explored (e.g. tailings volume reduction via iron recovery) alongside the practical technical and economic barriers. One of the major outcomes is that pressure filtration achieved ≈86% m/m (solids or ≈14 wt% moisture). At this moisture level, the cake remained 'sticky', and the flow moisture point (±12.5 wt% moisture) and the transportable moisture limit (TML) (±11.3 wt% moisture) were not achieved. Based on the material properties, the inability of pressure filtration to achieve the TML complicates material handling and ultimately the tailings transportation and final placement. A trade-off between this complexity and the additional water recovery should be closely considered on a case-by-case basis.

Keywords: *dewatering, paste, filtration, tailings, ESG, transportable moisture limit, flow moisture point*

1 Introduction

Mining is gradually transitioning from a linear industry focused solely on the extraction of primary valuable minerals/elements to a more circular system that aims to maximise the recovery, reuse and repurposing of resources already within the value chain. This shift is being driven by increasing environmental, social and governance (ESG) expectations which are reshaping how companies approach waste, water and resource optimisation. Mine tailings, once viewed purely as waste, are now being recognised as potential sources of value, both through secondary mineral and metal recovery and the responsible reuse/recovery of process water.

Within this broader transition, tailings reprocessing offers an opportunity to address several critical challenges simultaneously – reducing the volume of legacy waste stored in tailings facilities, recovery of valuable material historically missed due to technology/market requirements, and improving overall resource efficiency. However, the feasibility of such initiatives depends not only on the economic recovery of minerals, but also on the characteristics and manageability of the newly generated tailings. The Global Industry Standard on Tailings Management (GISTM) highlights the need for holistic tailings governance that integrates risk, water stewardship and long-term sustainability into every stage of the tailings life cycle. This can be achieved by developing dewatering and deposition strategies.

* Corresponding author. Email address: nicolener@fraseralexander.com

The case study presented in this paper forms part of an ESG-driven initiative at an iron ore operation in South Africa aimed at improving the productivity and sustainability of tailings management. Pilot-scale beneficiation test work was conducted to determine whether tailings volume reduction could be achieved through the upgrading of low-grade fine iron ore material – a feed type that remains globally challenging to beneficiate. Beyond the recovery of economic value, the study examined how this additional beneficiation step alters the properties of the newly generated barren tailings, particularly their response to different dewatering technologies and the implications for final deposition.

2 Literature review

2.1 Upgrading iron ore as a bulk commodity

Iron ore is considered a bulk commodity as it is mined and shipped in large volumes. Although a large volume of the mined material does not report to the mine's tailings storage facility (TSF), due to the large volumes mined, iron ore is still the third largest contributor to tailings material at 9% of the global tailings production (behind copper and gold at 46 and 21%, respectively) (Prasad 2024). Iron ore mining has a significant impact on the environment, and recent TSF disasters (some in iron ore) have renewed the interest from public and government agencies to address this impact through sustainable approaches. For 3 consecutive years (2022–2024), Ernst & Young (EY) identified ESG risk as the top-ranking risk for the mining sector. This meant that a trend was observed that mining companies were increasingly scrutinised on the 3 ESG indicators. While EY's 2024 survey positioned ESG as the leading sector risk and highlighted tailings and waste management as an area of heightened investor scrutiny, the 2026 outlook reflects a reframing toward operational complexity and capital discipline within which tailings management remains a critical control affecting operational resilience and stakeholder confidence (EY 2025). This means that tailings remain recognised as one of the most visible ESG indicators as all 3 pillars are combined (EY 2023).

To address this risk, in addition to managing the consequences of declining ore grades, iron ore mining companies have been focusing on improving productivity and sustainability (Holmes et al. 2022). This has resulted in the iron ore industry continuously fostering innovation and integration of new technologies into practice. As a result of this innovative approach, the level of technology adoption and innovation in this industry is highly advanced (compared to other commodities) and several new technologies (such as sensor based sorting and dry beneficiation routes) have already been adopted by leading companies to gain the benefits of reduced risk and increased financial return relative to their competitors (Holmes et al. 2022).

2.2 Fine mineral beneficiation

Across all commodities, the same statement is being repeated: the demand for mineral products is increasing while the grade is reducing and the mines are becoming deeper and more complicated (Cramer et al. 2004; Wang et al. 2014). This limitation is actively driving research and development (R&D) within fine material recovery technology resulting in novel technologies as well as innovative application of existing technologies. EY's 2026 top 10 business risks and opportunities clearly highlights how depletion and low-grade resources (related to risk 4 'resource and reserve depletion') is a powerful driver to accelerate investment and technology innovation.

One additional driver towards the beneficiation of fines, and the subsequent recovery of value from fines, is the potential to reduce tailings volumes. The main examples are the potential to recover fine iron ore or chrome minerals entrained in the fines in significant volumes. From engagements with clients on several projects over the last 5 years, Fraser Alexander has identified the typical yields required to be economically feasible to be above 30%. For the investigated bulk commodities, this holds significant ESG benefits as a reduction in the tailings volume is a reduction in the tailings management risk over the tailings lifecycle up to closure. Figure 1 presents a glimpse of the mainstream beneficiation technologies and their efficiency range that can be applied to the recovery of fine materials.

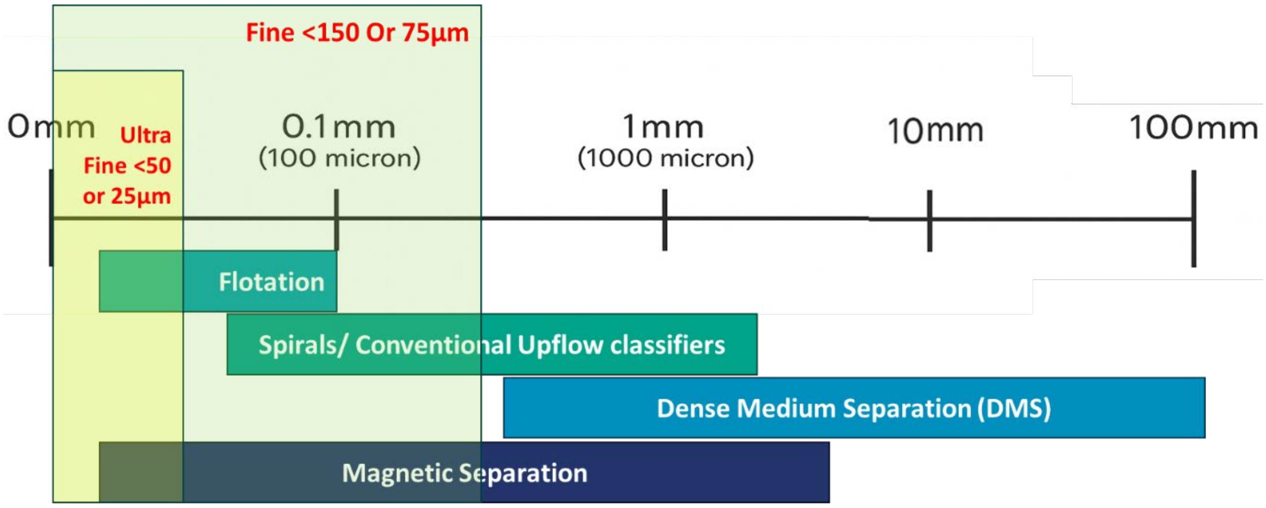

Figure 1 Guideline on the types of physical separation technologies used to beneficiate fine materials (modified from FineTech Minerals 2025)

Globally, the trend is for high-grade, easily accessible ore to be mined first. Vale, one of the world's largest iron ore producers, describes the evolution of the iron ore market in 3 waves (Fiscor 2015):

- 1940–1960: mining of high-grade hematite ore (6–50 mm).
- 1960–2015: depletion of easily accessible high-grade ore and the increased international competition resulted in the mining of lower grade ore.
- Post-2015: upgrading of even low-grade ore (±40%Fe) with high levels of contaminants. Reprocessing of tailings produced over the last 40 years.

This case study is aligned to the third wave mentioned above where fine tailings material are reprocessed to recover economic value and to reduce tailings volume. In addition, the study also considers the material changes that occurred during beneficiation/upgrading of this material and investigates the potential of improving water recovery at the mine.

2.3 Tailings dewatering

Tailings dewatering refers to the removal of water by some process between the point of resource extraction and the material's subsequent placement on the TSF. The degree of dewatering is captured in the tailings dewatering continuum (Figure 2) (Davies 2011). As water is removed, different tailings states are achieved, each with their own benefits and disadvantages as a function of transitioning from a fluid-like slurry with some soil in the water (tailings slurry) to a soil-like product with some water in the soil ('dry' filter cake).

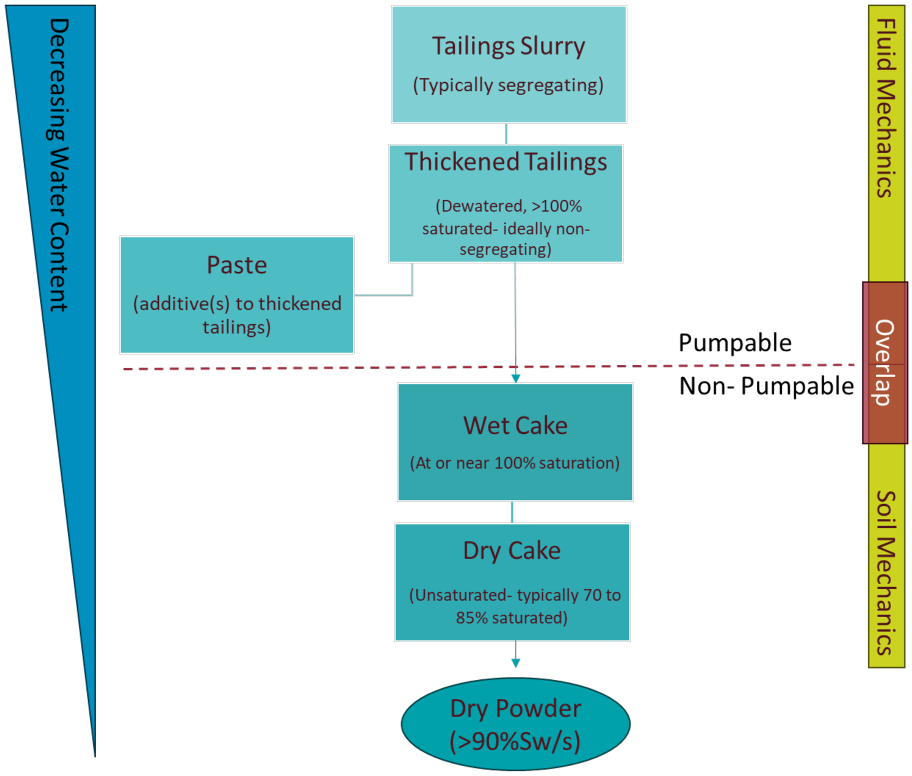

Figure 2 Tailings continuum (modified from Davies 2011)

To achieve the indicated states in the tailings continuum, several technologies can be applied. Figure 3 is an indication of the most popular technologies applied, but in general the points provided below identify the type of tailings and the dewatering technologies generally applied to achieve that specific tailings type:

- Conventional slurry tailings:
  - Conventional thickener
- Thickened tailings:
  - Flocculation and high density thickener
  - Cyclones
- Paste tailings
  - Deep cone thickener
  - Filtered tailings
- Filtered tailings
  - Horizontal belt press
  - Ceramic disc filters
  - Plate and frame.

Depending on the tailings material characteristics, a combination of the different technologies could be required to achieve the desired state. From Fraser Alexander's industry experience (R&D as well as operations), it is known that different filtration/dewatering technologies will produce a tailings product (cake) with different moisture contents. Although existing dewatering technologies are continuously improved and new technologies are introduced (some from other industries and applications), the ranges presented in Figure 3 can be used as a guide to achieve a final product/tailings moisture content.

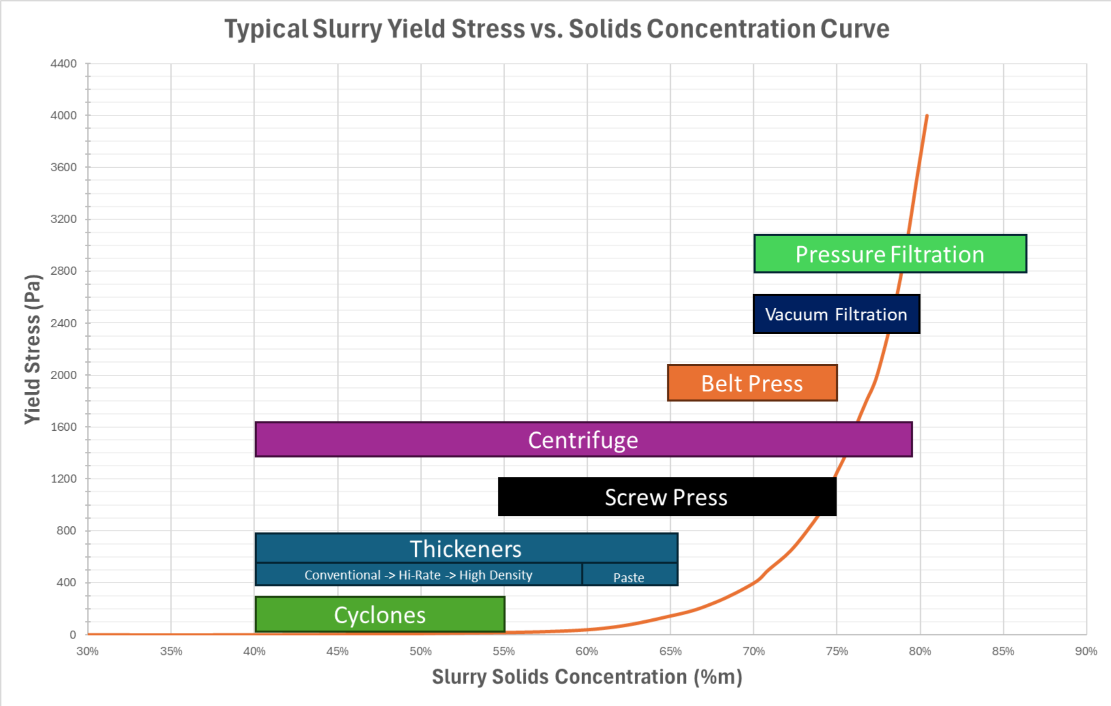

Figure 3 Dewatering capability of dewatering technologies (modified from Roux 2025)

The results presented in Figure 3 do not consider any interdependencies related to physical or chemical properties of material. The dewatering technologies and ranges depicted in Figure 3 are merely a guide to show the relative technology capabilities as available on the market. More details on how a material's specific properties can influence dewatering will be provided in the next section.

2.4 Influence of material characteristics during dewatering

The heterogeneity of mine tailings makes it extremely difficult to generalise on their dewatering capabilities. Although the dewatering capabilities will vary from site to site (often even within the same site), the most important physical and chemical characteristics that can have an influence on dewatering is listed in Table 1.

Table 1 Key physical and chemical parameters for filtering tailings (BHP Rio Tinto 2024; Cacciuttolo & Atencio 2022; Meneses et al. 2024; Vietti & Van der Linde 2024)

Physical properties	Chemical properties
Moisture content	Chemical composition (mineralogy and clay content)
Specific gravity	Clay properties
Particle shape	Feed water chemistry
Particle size distribution	pH and conductivity
Density	

Interdependencies of the parameters listed in Table 1 should not be overlooked and have a significant influence on how tailings material dewaters. Changing or adjusting one parameter could easily improve or reduce the filterability of material. An example of this is the work done by authors such as Vietti (2025) who has tracked the dewatering behaviour of different material. Vietti (2025) studied how clay content and related properties could influence dewatering, making a material more or less difficult to filter (Figure 4).

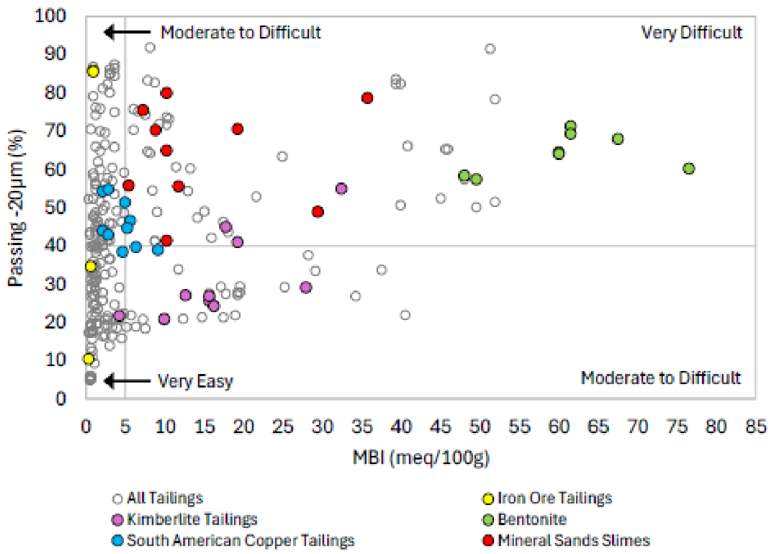

Figure 4 Tailings dewatering behaviour classification based on fines content and clay properties (Vietti 2025)

The data presented in Figure 4 illustrate the interdependency of particle size distribution (PSD) and clay content (specifically swelling or reactive clay content). These data were collected by test work conducted on South African tailings material and can be used as an indication on whether or not a certain material is compatible with filtration dewatering technology. Based on the data reported by Vietti (2025), a high-level assumption could be made that iron ore material would be very easy to moderately difficult to dewater by filtration. Although this graph gives an indication on which material will be easy to filter and which will be difficult to filter, it does not consider the extent of dewatering. Although a material could be easy to filter (refer to yellow dots for iron ore), it does not indicate the extent of the dewatering and whether the desired dewatering can be achieved or not.

3 Methodology

3.1 Aim

The aim of this case study was to evaluate the potential for upgrading iron ore tailings through physical separation techniques and to determine the ultimate implementable water recovery potential of the newly generated tailings material through dewatering. The approach followed for the beneficiation steps was batch pilot-scale test work focused on recovering fine and ultrafine iron-bearing material.

The tailings generated from the beneficiation process (hereafter referred to as the barren tailings underwent extensive dewatering test work to understand the dewatering capability of this specific material. Both the beneficiation and dewatering approaches followed an experimental design with the intent to replicate realistic and repeatable processing conditions.

3.2 Background of the case study

An iron ore mine in South Africa requested a pilot trial to investigate the potential to improve productivity and sustainability through the recovery of iron material from their tailings. The trial was able to recover additional iron ore material at the targeted grade. It should be noted that the mine requested that some components of the trial be kept confidential, such as their identity and the beneficiation aspects, therefore this case study will not elaborate on that portion of the trial. The focus for this case study is aligned to the dewatering test work that was conducted on the newly produced barren tailings.

In addition to value recovery, a key driver for this trial was water recovery. South Africa is considered a water-scarce country as it receives around half of the global average rainfall per year (±450 mm/year) (Republic of South Africa 2026). This water limitation combined with the country's hot climate creates an enabling environment for conventional tailings disposal. It should, however, be noted that the country's arid and semi-arid conditions necessitate water conservation, with TSFs playing a crucial role in recycling process water. However, high evaporation rates exacerbate water losses, particularly in warmer regions. While the dry climate supports upstream construction by facilitating rapid tailings drying, it also leads to increased dust emissions from tailings beaches, posing environmental and health risks in windy areas (Davies 2011; Simms 2023). Taking the water restrictions into consideration, the aim of this case study is to elaborate on the material's amenability to dewatering and to consider the best water recovery solution, be it conventional wet deposition, a paste facility, or a dewatered dry stack tailings facility.

3.3 Beneficiation experimental design

A pilot-scale beneficiation facility was constructed to evaluate the potential for recovering additional iron value from the tailings stream. The work followed a semi-batch process designed to simulate continuous industrial operation while maintaining experimental control.

Due to the proprietary nature of the beneficiation process, detailed descriptions of the flow sheet and operational parameters are not disclosed in this paper. The focus of this case study is therefore limited to the characterisation and dewatering performance of the barren tailings produced by this process.

3.4 Dewatering experimental design

The dewatering test campaign was conducted by a reputable consulting laboratory using standard laboratory-scale dewatering methods. These tests aimed to quantify the dewatering capability of the barren tailings, evaluate achievable moisture contents, and identify suitable dewatering technologies. Subsequently, pilot-scale filtration tests were performed at a filter press manufacturer to assess the scalability of the laboratory results and validate performance under semi-industrial conditions. The dewatering test work scope included the components listed in Figure 5.

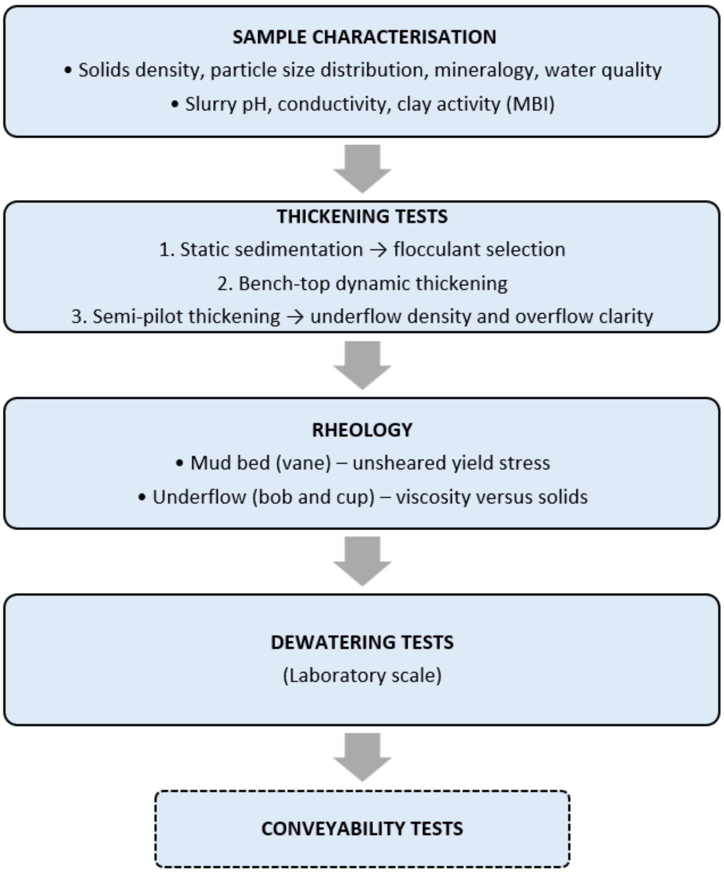

Figure 5 Generic dewatering test work scope

The methodology adopted in this study followed a structured, experimental approach aimed at producing results that can be scaled to real life conditions. The following section presents and discusses the outcomes of these test programs and their implications for tailings management and water recovery.

4 Results from an iron ore tailings case study

4.1 The barren tailings

During the trial, 35 tonnes of dry iron ore tailings were beneficiated to produce a barren tailings representative of the applied flow sheet. The barren tailings sample constituted of a hematite rich material (>80%). The PSD indicated that the sample was very fine with ±75% or the material passing 25 µm and only 18% of the material being larger than >75um (P_{80} = 56 µm).

4.1.1 Dewatering test work: paste

Laboratory-scale settlement and dewatering test work was conducted following the structure presented in Figure 5. The test work confirmed that the flocculant applied by the mine is still efficient on the barren tailings and was used for all relevant test work. To understand the achievable solids density or dewatering achievable for a paste facility, bench-scale dynamic thickening test work was conducted. This test indicated that underflow solid concentrations of around 63–66% m/m (% solids) could be achieved when considering paste deposition. Underflow rheology results classified the barren tailings as a Bingham Plastic which indicates that the material could still be successfully pumped at this range, but that the yield stress increases sharply beyond 64–70% m/m (% solids) making pumping increasingly difficult.

4.1.2 Dewatering test work: scoping study

The only dewatering technology applied in the most recent pilot trial was pressure filtration. This was selected based on a prior scoping study conducted on similar material from the same mine. The scoping study indicated that vacuum filtration was not feasible (both horizontal belt vacuum filtration and disc filter vacuum filtration). Test results for each of the 3 dewatering technologies tested in the scoping study are displayed in Table 2.

Table 2 Dewatering test work conducted during a prior scoping study showing the percentage solids in the filter cake

Pressure filtration	Horizontal belt vacuum filtration	Disc filter vacuum filtration
86–90%m	75–85%m	65–86%m

The conclusion from the scoping study was that the only feasible option to dewater the material will be by means of pressure filtration. It is for this reason that the current case study only conducted pressure filtration test work.

4.1.3 Dewatering test work: lab-scale pressure filtration

Laboratory-scale pressure filtration test work conducted on the barren tailings sample aimed to determine the achievable cake solids concentration, filtration rate, and filtrate quality under varying feed conditions and operating pressures.

Filtration was performed using a double-sided horizontal filter chamber unit equipped with interchangeable filter cloths. Feed slurry was introduced under controlled pressure until a uniform cake formed between the plates. Once filled, a membrane squeeze and air-blow step were applied to further dewater the cake. The main test variables included:

- Feed mass solids concentration: 55, 60, and 65% m/m
- Feed pressure: 7 bar and 14 bar

- Membrane squeeze pressure: up to 12 bar
- Cake thicknesses: 35–60 mm
- Cake blow pressure: 7 bar for 10 minutes.

Filter cloth screening identified Clear Edge PX 657-95 as the most suitable material, offering good filtrate clarity and consistent cake release.

Results indicated that increased solids feed concentration improved cake dryness but did not significantly shorten the filtration time. The increased feed pressure from 7 to 14 bar also did not notably improve cake dryness or filtration time and the maximum achievable mass solids concentration (for both pressures) were approximately 86% m/m (solids). Similarly, incorporating a 12 bar membrane squeeze step after a 7 bar feed cycle showed no meaningful benefit. In some cases, the squeeze caused tighter packing of fine particles, impeding further moisture release. This behaviour is attributed to the material's very fine PSD (P_{80} ≈ 56 µm; 75% passing 25 µm), which forms a low-permeability cake that limits drainage under higher pressures. The final cakes were firm and exhibited structural stability, with dry densities averaging 2,200–2,350 kg/m^3.

4.1.4 Dewatering test work: pilot-scale pressure filtration

Pilot-scale pressure filtration tests were conducted to verify laboratory-scale results and to generate design data for a potential full-scale filter press installation. The testing formed part of the broader dewatering study aimed at evaluating the filtration behaviour of the barren tailings under practical operating conditions.

Filtration was performed using a pilot plate-and-frame unit equipped with both membrane squeeze and air-blow capability. The unit included interchangeable 10 and 20 mm filter frames, and trials were completed using 2 filter cloth types of which the FQWP1043 cloth demonstrated superior performance in terms of filtrate clarity and cake release. The feed slurry was prepared using process water and the mine's own flocculant at a dosage established during the laboratory test work.

Three target feed densities were prepared for testing, approximately 55, 60, and 65% m/m (solids by mass), representing the expected range of thickened underflow densities achievable in plant operation. The press was fed via an air-operated double diaphragm pump which could deliver a terminal pressure of 6 bar, representing the mechanical limitation of the pilot unit. Membrane squeeze and air-blow steps were subsequently applied at the same pressure once the cakes were formed.

- Feed mass solids concentration: 55, 60, and 65% m/m (solids)
- Feed pressure: 6 bar
- Membrane squeeze pressure: 6 bar
- Cake thicknesses: set at 10 or 20 mm
- Cake blow pressure: 6 bar for 10 minutes.

Each test cycle followed a defined sequence of cake formation → membrane squeeze → air-blow, with a fourth test including an additional air-blow prior to squeezing, followed by a final air-blow to assess the effect of extended drying. The modified cycle resulted in only a marginal improvement in cake dryness (approximately 1.7% lower moisture content) but required over double the total filtration time. Filtration time, feed solids concentration, and filtrate clarity were recorded for each cycle, and samples were taken to determine cake moisture and density.

4.1.5 Dewatering test work: comparison

The pilot-scale filtration results correlated strongly with the laboratory findings, confirming that achievable cake solids concentrations ranged between 83.1 and 87.2% m/m solids (12.8–16.9% moisture). The driest and most structurally stable cakes were obtained from feed at 65% m/m (solids), while lower-density feeds produced softer, more pliable cakes. All cakes remained intact following discharge, exhibiting rubbery, cohesive textures consistent with the fine-grained, tri-modal PSD (P_{80} ≈ 56 µm) identified during sample characterisation. The material handling results obtained during the pressure filtration test work will be discussed in the next section.

4.1.6 Filter cake conveyability test

To investigate the conveyability (handling) and stability (flow behaviour) of the filtered barren tailings, the flow moisture point (FMP) and transportable moisture limit (TML) were determined. The FMP defines the moisture content at which the material begins to lose its structural integrity and flow under its own weight, while the TML, typically 90% of the FMP, represents the upper safe limit for transportation and mechanical handling. These parameters are critical for evaluating conveyability and stacking performance, as materials filtered above the TML are prone to cohesive behaviour and may exhibit flow blockages or instability (such as liquefaction) during transfer and deposition.

The filter cakes (lab-scale) showed an FMP of 12.5% (87.5% m/m solids) and a TML of 11.3% (88.7% m/m solids). Since the pressure filters could not achieve moisture contents below the FMP, the material is classified as difficult to dewater for filtered stack applications. The inability of the material to achieve the FMP and TML indicates that a safe limit for transportation and mechanical handling will not be reached. In addition, the materials handling properties indicated that the tailings were cohesive and difficult to handle once filtered.

To better understand the material handling challenges that could affect transportation via conveyor belt and conveyor transfer chutes, additional test work was conducted. The results indicated that a filter cake with 86% m/m (solids) will not flow but would pack vertically onto itself. This build-up will result in blockages in the outlet of the conveyor transfer chutes. The sticky filter cake material will require mechanical assistance (compressed air pulsing, vibrating chutes and specialised liners) to ensure that no blockages occur in bins, hoppers and transfer chutes. In addition to the risk of blockages, the filtered material exhibited high cohesion and showed poor flow though apertures. The results obtained during the pressure filtration test work is displayed in Table 3.

Table 3 Summary of pressure filtration results

Parameter	Range/observation
Feed pressure	7 bar and 14 bar
Feed solids	55–65% m/m
Cake thickness	35–60 mm
Final cake solids	81–87% m
Dry cake density	2,130–2,350 kg/m³
Cake blow pressure	7 bar for 10 min
Filtrate clarity	<1,000 ppm suspended solids
Optimal cloth	Clear Edge PX 657-95
FMP/TML	12.5%/11.3% moisture (87.5–88.7% m/m solids)

Although filtered tailings are increasingly promoted through global frameworks such as the GISTM, the findings from this study indicate that their practical application is not always feasible. The results clearly show that the filtered barren tailings would be challenging to handle and manage under operational conditions given its cohesive nature and moisture content above the FMP.

4.1.7 Geotechnical test work summary

In addition to the dewatering test work, geotechnical tests were conducted to understand if the filtered material could be safely stacked. In summary (not the focus of this paper), the geotechnical properties of the barren tailings indicated that the mechanically stacking of a ‘dewatered tailings cake’ is not viable unless the barren tailings can be consistently dewatered to moisture contents between 9.1–11.5% metallurgical moisture content. This was not achieved. Geotechnical test work conclusions were based on the observations from the liquid limit constrains, the moisture density relationships as well as the material’s California bearing ratio performance.

5 Discussion

The results from the laboratory and pilot-scale dewatering test work confirmed that the barren iron ore tailings can be effectively dewatered through both paste thickening and pressure filtration. Each method achieved a substantial reduction in water content compared to conventional tailings deposition. However, while pressure filtration produced slightly higher solids concentrations, the material’s handling characteristics and the associated cost implications suggest that a paste tailings product may be the more practical solution for this operation.

The bench-scale thickening test work showed that underflow solids concentrations of around 63–66% m/m (solids) could be achieved using a paste thickener. Rheology results indicated that the material could still be pumped at these densities although the yield stress increased sharply between 64–70% m/m (solids). This suggests that a paste product could be transported using conventional positive displacement pumps without significant flow or stability issues. In contrast, pressure filtration achieved up to 86% m/m (solids) (14 wt% moisture), but the resulting cake remained cohesive, sticky, and difficult to handle. Even at this moisture level, the filter cake still had a moisture level above its FMP (12.5 w% moisture) and TML (11.3 wt% moisture), classifying it as difficult to dewater sufficiently for filtered stack disposal. The material handling results indicated the even below the TML the filter cake material would still be difficult to handle as it would be prone to causing blockages.

From an operational perspective, these results highlight the trade-off between maximum water recovery and handling practicality. Although pressure filtration can achieve slightly higher solids content and therefore greater water recovery, it also introduces substantial challenges in conveying, stacking, and equipment maintenance. The cohesive nature of the filtered product complicates transfer through chutes or conveyors and would likely necessitate the use of modified and well-maintained conveyors/chutes up to the discharge points. Furthermore, the filtration process itself is capital-intensive and energy-demanding, with high ongoing operational costs associated with cloth maintenance, cycle times, and consumables. The transportation of filtered tailings in this case study is seen as fatally flawed and filtration should only be considered if some form of hybrid system (filtration plus an additional dewatering step) is considered. The economic feasibility of such a hybrid system would need to be compared to the paste system.

By comparison, the paste thickening route presents a more balanced approach. While the achievable solids content (approximately 63–66% m/m [solids]) is lower than that of filtration, it still represents a significant improvement over conventional slurry deposition, which typically achieves around 55–58% solids. Paste disposal offers a notable reduction in water loss through improved water recovery and lower evaporation from the deposited tailings beach. It also requires less complex infrastructure compared to filter presses, with fewer moving parts and no filter presses or cloth replacements, which translates into lower opex and capex. Paste thickeners also allow for continuous operation, reducing process interruptions, and simplifying tailings management.

In addition to its economic advantages, paste deposition provides operational flexibility and environmental benefits. The paste material can be gravity deposited or pumped, reducing dust generation and improving deposition control. Its higher solids content compared to conventional slurry also allows for improved beach stability, the absence of water pooling, and smaller containment footprints. In South Africa, where evaporation rates are high and water scarcity is a critical challenge, the adoption of a paste tailings system could contribute meaningfully to water conservation without the technical and financial burdens associated with filtration.

Overall, the test work clearly demonstrates that a paste tailings product offers the most practical balance between water recovery, cost, and operational manageability. The paste option would achieve a measurable improvement in water efficiency compared to traditional wet deposition, while avoiding the handling difficulties, capital intensity, and mechanical complexity of a full filtration system.

6 Conclusion

Iron ore, although a bulk commodity, is also considered a significant generator of tailings. The reprocessing trial discussed in this case study formed part of a broader ESG-driven initiative to reduce the environmental footprint of tailings while improving resource recovery and water usage efficiency. The beneficiation component successfully recovered additional iron value from legacy tailings, thereby reducing overall tailings volumes. However, the focus of this study was on the dewatering characteristics of the newly produced barren tailings and its potential for alternative tailings deposition approaches under arid South African conditions.

The dewatering test work demonstrated that while pressure filtration achieved high solids concentrations of approximately 86% m/m (14 wt% moisture), the resulting cake remained above the FMP (12.5 wt% moisture) and the TML (11.3 wt% moisture). At these moisture levels, the material was cohesive and the stickiness of the material significantly complicated its handling and placement. The operational complexity, high capital cost, and ongoing maintenance demands associated with filtration limit its overall practicality despite its improved water recovery potential.

By comparison, paste thickening achieved underflow solids concentrations of 63–66% m/m (solids), producing a more workable and pumpable material. Although slightly lower in solids content, paste deposition still represents a major improvement over conventional slurry disposal while offering a more balanced outcome in terms of cost, operability, and environmental benefit. It provides a meaningful reduction in water losses with lower capex and opex, continuous operation, and simpler infrastructure requirements.

Considering the water-scarce nature of South Africa's mining regions, a paste tailings approach presents a practical and sustainable alternative to filtration. It aligns with the mine's broader ESG objectives by reducing water consumption, improving tailings stability, and lowering long-term environmental risk. The findings of this case study therefore suggest that while filtration can deliver marginally higher water recovery, the additional complexity and cost may not justify its adoption. For this material, and under similar climatic and operational conditions, a paste tailings solution offers the most appropriate balance between technical feasibility, economic efficiency, and sustainable water management.

Results obtained from this study indicated that filtration could not achieve the TML which complicates material handling and ultimately tailings transportation. Inputs from geotechnical test work on this material also indicated that mechanically stacking of this material is not viable due to ineffective primary dewatering via filtration.

Acknowledgement

We would like to express sincere appreciation to our client for granting permission to use the outcomes of this trial and for their continued support throughout the project. Their collaboration and openness made it possible to share valuable insights from the work. Gratitude is also extended to Fraser Alexander for the opportunity to conduct the test work and present the results as part of the company's ongoing commitment to innovation and responsible tailings management.

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