Case Study: Engineering to the Limits to Generate Reclaimed Tailings Paste Fill

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Abstract

This case study discusses a uniquely challenging design and implementation of a reclaimed tailings paste fill project. The mine operator identified the need for paste fill in a new ore zone and chose to refashion an incomplete hydraulic fill plant into a reclaimed tailings paste fill plant. A partially complete 850 m borehole was planned, however many challenges were encountered in the completion of the borehole. The borehole was abandoned at the latter stages in the project and an overland pumping and shaft pipe system was engineered to tie into the already complete underground paste reticulation. Underground distribution pushes the limits of gravity distribution with > 1.6 km of horizontal pipework and only 850 m of gravity head available.

Design and implementation was completed on a fast-track schedule which presented many challenges in undertaking design whilst implementing and preparing for operation in keeping with the stringent requirements of a top-tier mining company. The overall system design pushes the technical limits of generating quality paste fill from reclaimed tailings and transporting it through an arduous pumping and gravity reticulation network, where small changes in rheology have dire consequences on the flow of paste.

Key words: reclaimed tailings paste fill, overland pumping, shaft paste, underground gravity paste reticulation

Introduction

Newmont (previously Newcrest) Telfer Mine discovered a new ore zone that was well suited to utilising paste backfill in 2021. The ore zone (Figure 1), consisted of 15 m wide stopes ranging from 7–40 m high and 30–70 m long. With a short (< 2 years) design life, the paste system came with the challenge of developing a solution that matched the constraints of the mine. MineFill Services was contracted to provide the turn-key paste system solution, including the technical backfill, paste plant and underground distribution design aspects for the paste system, construction of the paste plant, and commissioning and operator training for the reclaim paste backfill system.

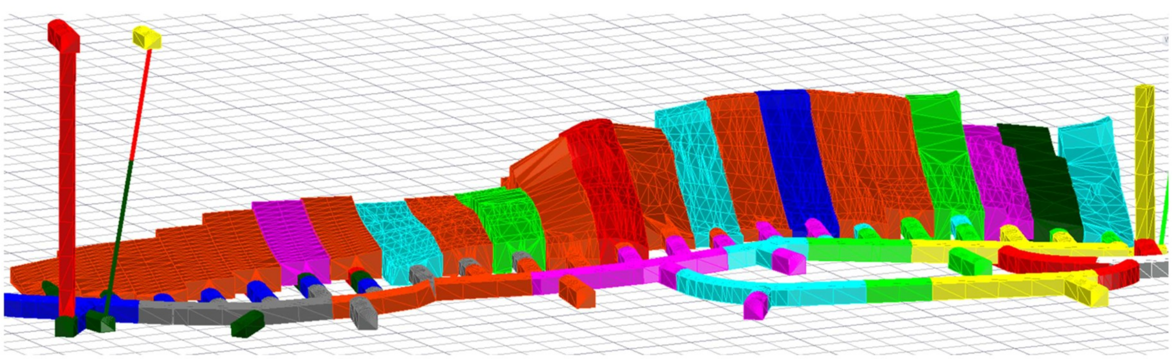

Figure 1. Telfer Rey underground ore zone isometric view.

Telfer partially completed a cemented hydraulic fill (CHF) plant in 2017. The plant was structurally and mechanically installed, however it was not commissioned due to changes in the mine plan. Upon discovery of the Rey ore zone, Newmont elected to repurpose the CHF plant infrastructure to a paste plant. This decision was largely driven by the existing 850 m borehole that had been pilot-drilled in 2017.

Paste Plant Design

Tailings material characteristics

Telfer Mine has been in operation for almost 50 years, with tailings disposal located in surface tailings storage facilities (TSF). There are seven TSFs, with TSF7 being the current active facility for the mill tailings disposal. The historic dams have all been closed and/or capped for rehabilitation. For ease of permitting, TSF7 was chosen for the sourcing of tailings material to supply Rey paste plant. An extensive material testwork campaign was undertaken on the material sourced from TSF7 quadrant 2 (Figure 2).

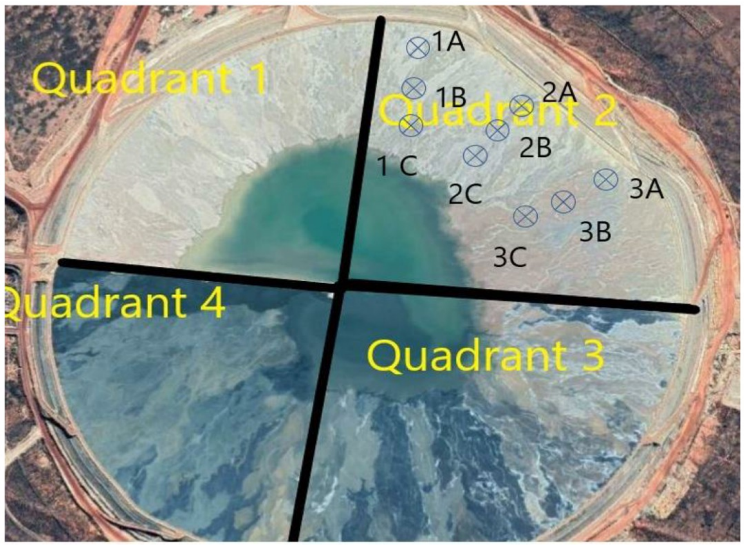

Figure 2. Active tailings storage facility sampling locations for paste testwork.

Material characterisation indicated a well-graded particle size distribution in the TSF7 source tailings for making paste, ranging from 28–40% passing 20 µm. Mineral composition indicated a favourable composition of quartz and dolomite. However, the presence of muscovite and sulphides posed risks to the paste rheology and long-term strength characteristics. The sampled tailings also presented a wide-ranging pH from 3.5–7.6. To combat these risks, MineFill conducted test work to investigate and develop strategies for operating the paste system. Due to the challenging paste reticulation geometry, a key strategy decided from the testing was to target low-solids content paste (Figure 3).

(a) 71.5% Solids, 245 mm Slump **(b) 70.0% Solids, 255 mm Slump**

Figure 3. Paste slump test work targeting low-yield stress paste.

Process design

The paste system uses a traditional reclaim tailings process (Figures 4 and 5) to generate 80 m^3/h of paste backfill with up to 8 wt% binder addition. Reclaimed tailings from the TSF are screened to remove any oversize (> 20mm) material and break up clumps of tailings from the TSF harvesting, stockpiling and trucking process. Tailings are fed into the plant by a wheel loader into a feeder conveyor. The tailings are weighed and moisture content measured by a contact-type moisture probe before entering the twin-shaft paste mixer. Low-heat cement, a blend of Portland cement and ground granulated blast furnace slag, is added to the tailings in the paste mixer, as well as water. The cement and water are also measured by mass flow meters to achieve a consistent solids content paste. The accuracy of the paste solids content is fully controlled by the process control system with regular sampling by the plant operators. The automated control system coupled with regular operator checks is paramount to the success of the operation due to difficult paste distribution geometry and mineral composition both posing risk of blockage.

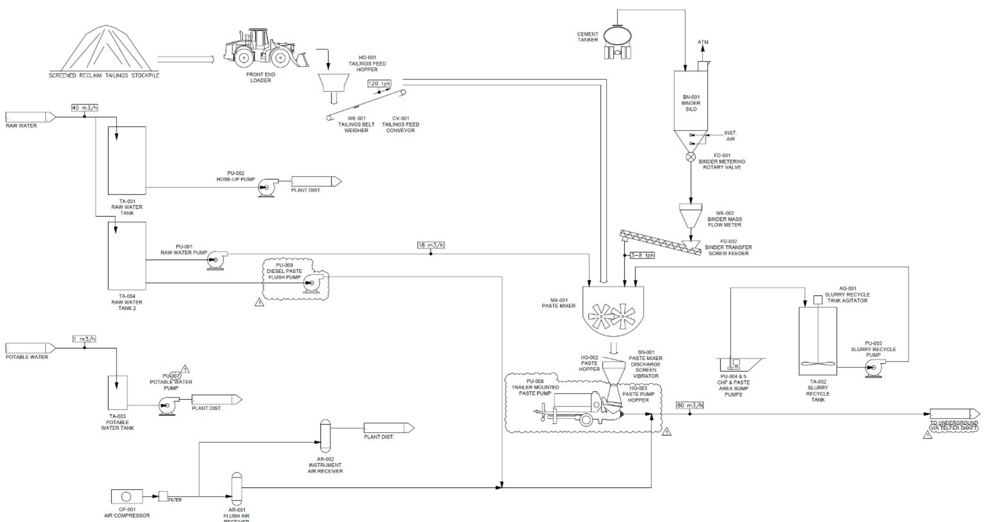

Figure 4. Rey paste plant process flow diagram.

Figure 5. Rey paste plant.

Due to challenges in the borehole drilling process, a pump was added to the process design at a late stage of the project execution. This resulted in redesign of both the surface plant and revisiting of the underground distribution system design to ensure that existing design conditions and materials were still fit for purpose.

Paste Distribution

Underground distribution geometry

At the outset of the project, paste was intended to be delivered to the underground mine through the existing, partially completed borehole at the historic plant location. However, the plant location was not favourable for delivering paste to the Rey ore zone; due to the design life for the project and existing infrastructure at the historic site, the surface plant location was maintained in favour of developing a new paste plant site. As a result, an extensive reticulation geometry (Figure 6) was required to deliver paste to the stopes. The surface to underground borehole is nominally 850 m vertical and the underground pipework extends for approximately 1.6 km. To add further challenge to the distribution, the final 700 m of pipework is sloping uphill.

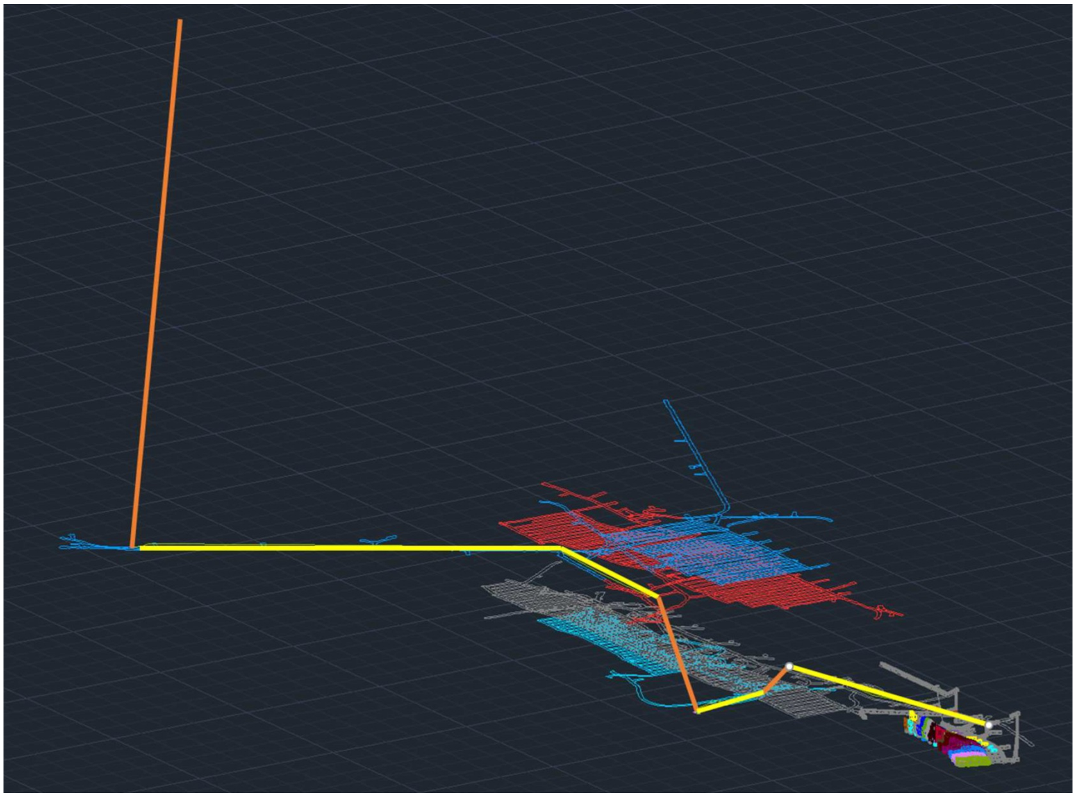

Figure 6: Underground paste distribution isometric view

With the risks presented by the tailings composition and difficult reticulation geometry, a large amount of instrumentation and valves were installed throughout the underground pipework. The instrumentation provides real-time feedback of the system pressures and flow to the plant operators. In the event of a blockage, dump valves along the pipeline allow for multiple dump locations to provide flexibility where paste is dumped so that flushing of segments can be achieved and a full system blockage is avoided. Figure 7 shows the various dumping and instrumentation locations.

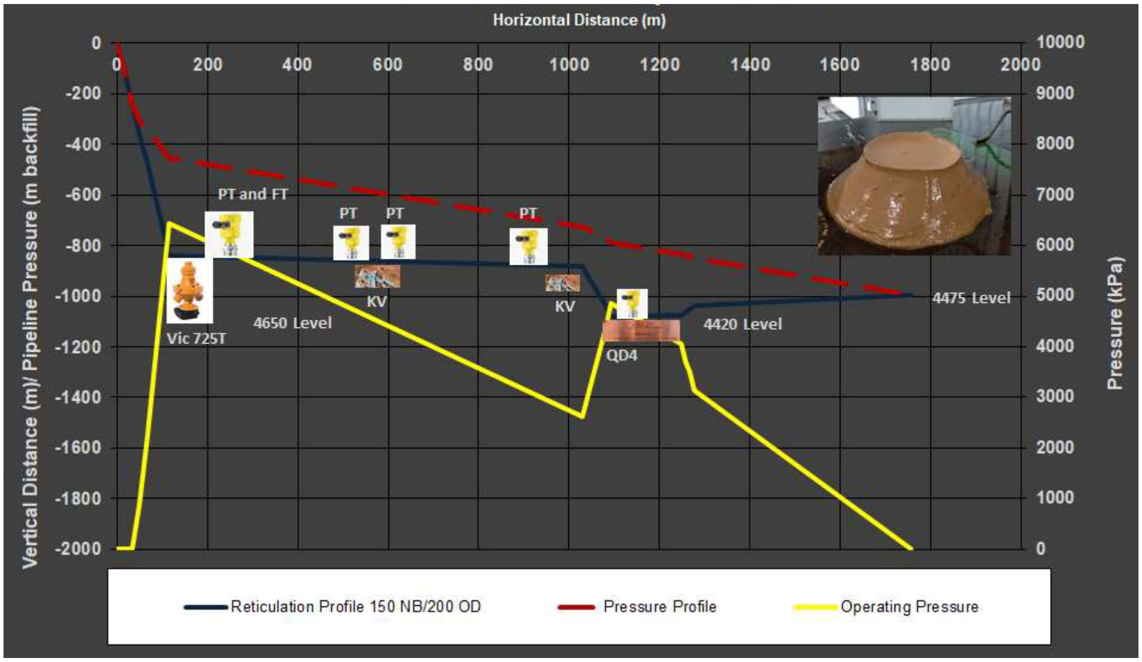

Figure 7: Underground reticulation flow model, instrumentation and valving

Overland pumping

Due to the borehole having been abandoned 7 years before the paste project and unstable ground conditions, the gravity borehole was unable to be cleared and finished for gravity paste delivery. In parallel to the drilling activities on the borehole, an overland pumping system design was developed to transport paste from the plant, nominally 300 m to the active Telfer Shaft (Figure 8).

Figure 8: Overland pumping system on plant site.

Time constraints of the project meant that a trailer-mounted concrete pump was selected for use in the overland pumping duty (Figure 9). The pump was fitted with automated speed control, however no pulsation dampening system was installed, again due to time constraints of the project. This necessitated a robust overland pipeline to handle the pump pulsations and potentially high pressures that can be generated in a blockage scenario.

Figure 9: Concrete pump within paste plant.

The addition of a pump to the paste distribution system occurred after the underground reticulation pipework had been installed. For this reason, the design of the system was to maintain a gravity distribution methodology.

Shaft delivery

To avoid the need for upgrading the underground paste piping system, second paste hopper was designed and installed at the Telfer Shaft collar (Figure 10). The paste hopper retains a constant level of paste being received from the overland pumping system and delivers it to an induction hardened pipe within the shaft. The 40 T of shaft pipe is primarily supported at the bottom of the shaft on a static support. A secondary hydraulic support system, designed to take the full load of the shaft pipe, is located at the top of the shaft provides a suspension system for maintenance activities of the shaft pipeline as well as protection in the event of a failure in the shaft pipe due to erosion.

Due to the criticality of the ore shaft to remain operable for the mining operations the shaft paste pipe was designed with a secondary containment shroud system to prevent spillage within the shaft and most importantly onto the winder ropes. As the shaft pipe presented the highest risk to the overall mine operations in the event of a blockage, a specialty piston dump valve was installed at the toe of the shaft pipe. The valve is hydraulically actuated and further supported with a battery backup system to ensure it can be locally operated even if mains power and remote communications are lost.

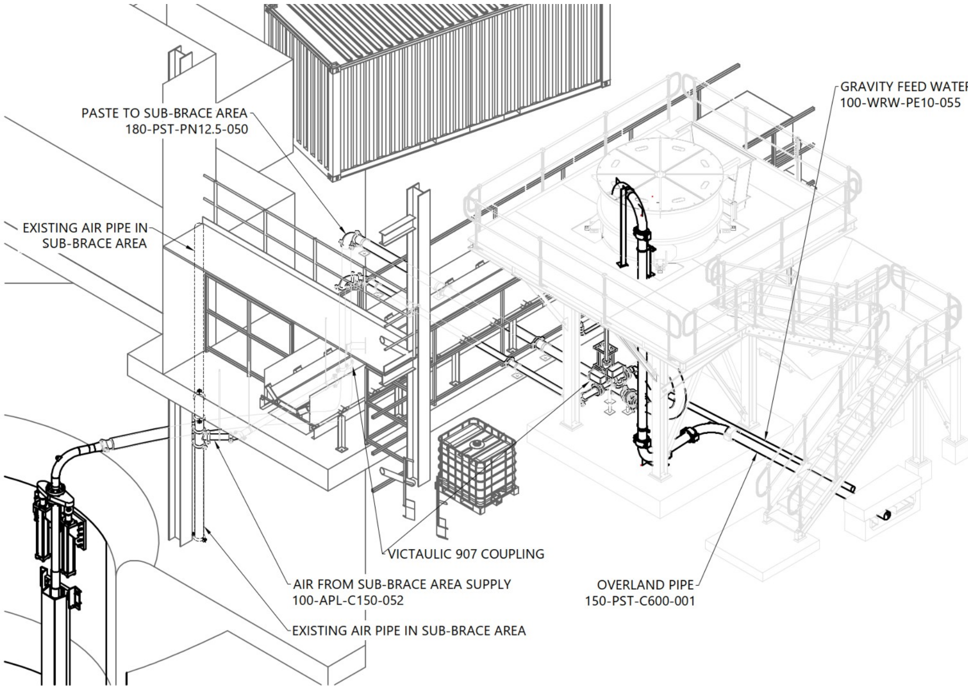

Figure 10: Telfer Shaft collar paste infrastructure

Stope Filling Considerations

The Rey ore zone presents in somewhat of a pyramid shape, with a large footprint area and tightening to a narrow tip at the top (Figure 11). In keeping with the range of other project challenges, the stope shapes presented challenges in the way of maintaining operational mining access in the ore drive whilst paste filling occurs, as well as placing paste into the stopes with no visibility due to a blind downhole fill hole. Due to the possibility of over pressurising the bulkheads during (tight) filling, a paste hopper is used at the fill point to ensure the full reticulation head pressure is not exerted on the fill mass and subsequently the bulkhead.

Critical to the paste filling and containment design to ensure safe operation of the Rey paste system is to mitigate risk of fill egress and minimise exposure of personnel to this hazard. Therefore, two forms of engineered fill structures are in place at all times during filling. Extensive bulkhead design work completed by MineFill Services determined accurate strength to height relationships (Figure 12). The calculations provided minimum containment bund volumes so that mining downtime was minimised whilst plug pours occurred.

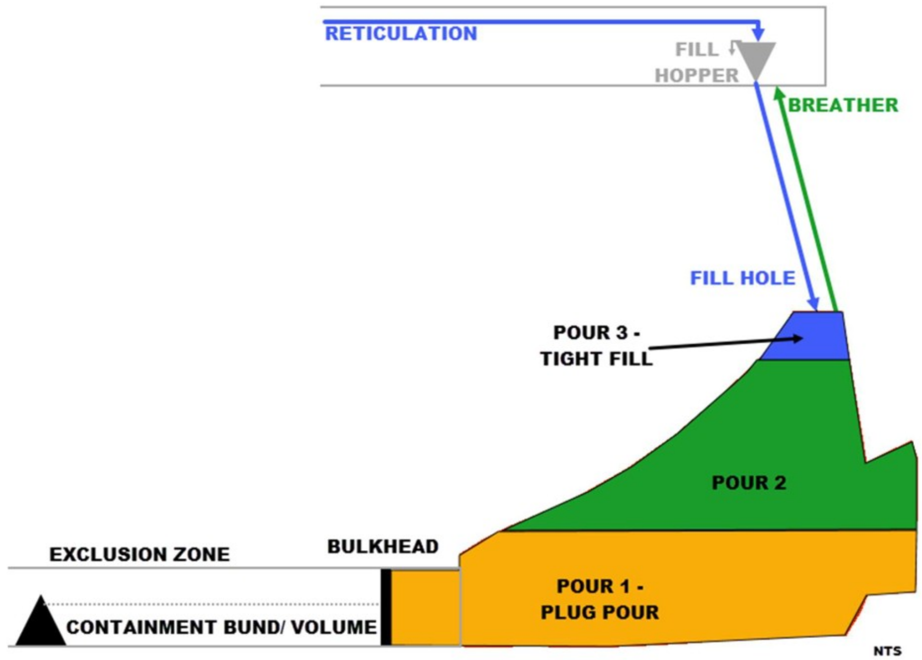

Figure 11: Typical stope configuration in Telfer Rey mining area.

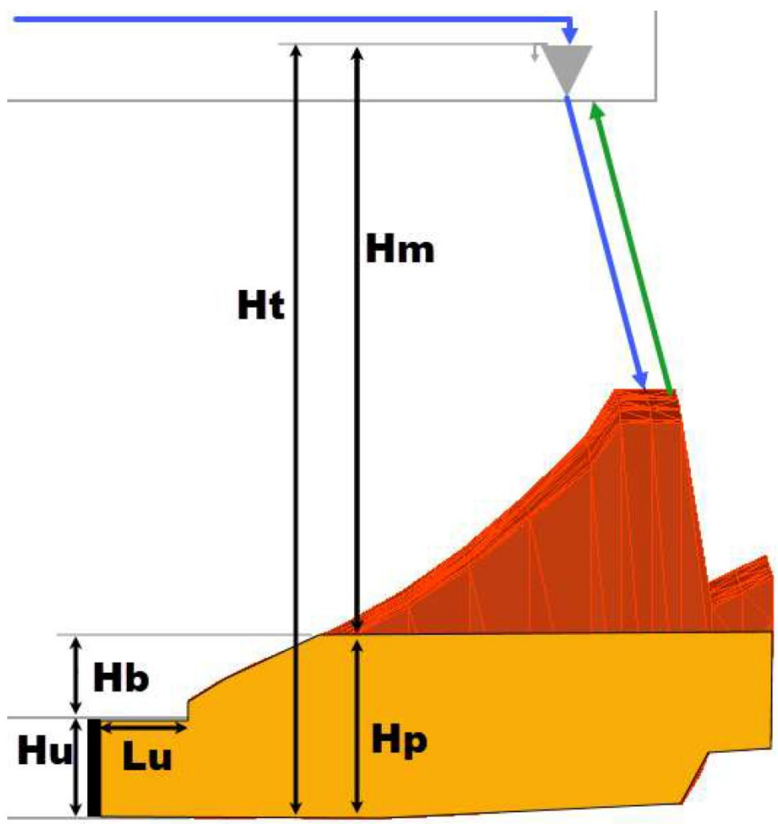

Figure 12: Schematic indication of key dimensions of stope bulkhead design.

In addition to calculated bulkhead strengths and stope volumes, real-time instrumentation is utilised on the bulkhead walls to monitor the stress on the wall and gather further data to continually improve the theoretical calculations. Video monitoring is used extensively in the underground paste system: at the shaft collar, shaft toe piston dump valve, reticulation dump locations, stope fill hopper and bulkhead. The live video feedback aids the operators considerably in ensuring the system operates smoothly and safely.

Successes and Setbacks

Implementation of the Rey Paste System set out on a very tight schedule. The design and implementation of such a challenging paste system in the time frame was always going to be difficult. Even with many challenges that arose along the way, the project execution ultimately resulted in a successful paste system that met the mining needs. With the setback of the borehole failure leading to a system design change (to include the overland pumping system) and a project stoppage of around 8 months, an adjusted project duration of just over 12 months from conception to first paste was achieved, seen by both MineFill and Newmont as a success.

The aftermath of COVID-19 is still being felt across the world with inflation, as well as supply chain and labour shortage difficulties. All of these played significant roles in the delivery of the project. Budget creep was difficult to control while continually having to juggle limited resources both on and off site.

Conclusion

The Newmont Telfer Mine Rey Paste System was successfully designed and constructed by MineFill Services with first paste produced in early 2024. The paste system consists of an 80 m^3/h reclaimed tailings paste fill plant that has been retrofit to a partially completed CHF plant. Paste is transported by a twin-piston concrete pump for 300 m, down an operating 850 m ore shaft, along 1.6 km of horizontal pipework to be finally deposited into the Rey stopes via blind downholes.

The paste system is uniquely challenging in all facets from the tailings material composition, through the paste system configuration, and underground mining geometry. With all of the challenges presented within the project, MineFill Services successfully commissioned the system to the high standards of Newmont.

Acknowledgement

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