

# Meandu Mine Dry Tailings Solid Bowl Centrifuge Design Installation and Commissioning

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## ABSTRACT

The Meandu open-cut mine is owned by Stanwell Corporation Limited (Stanwell) and is located in the Tarong Basin, 180 km north-west of Brisbane, in Queensland's South Burnett region. The mine is the sole supplier of coal to the adjacent Tarong power stations, also owned by Stanwell, with a generating capacity of 1843 MW. Coal is processed in a coal handling and preparation plant (CHPP). Raw coal can be by-passed or washed in a two module jig plant at a rate of 1800 t/h.

Currently tailings are thickened and disposed of in a conventional tailings dam. Due to optimisation changes in the life of mine plan, and the significant expected environmental benefits, dry tailings disposal was explored to see if tailings dewatering offered benefits to the operation over the long term. As a long term solution, Meandu has investigated options to dispose of dried tailings with the other coarse CHPP rejects, ensuring that another large tailings dam will not be required for the remaining life of mine.

After completing preliminary investigations into various dry tailings technologies, Meandu selected the solid bowl centrifuge technology. Test work was conducted on site, using a pilot scale solid bowl centrifuge, to confirm the suitability of the technology to dewater the thickener underflow. Stanwell engaged Sedgman Pty Limited for the design, supply, construction, installation and commissioning of the equipment.

The project was started in May 2017, with acceptance of the first solid bowl centrifuge in late December of the same year. Cake total moisture below 36% with clear effluent has been achieved. Further optimisation of flocculation addition and operation of the Alfa Laval P3-10070 are being progressed.

This paper will discuss pilot testing, main components of the plant design and commissioning, as well as the key elements that contributed to the successful outcomes for the project.

## INTRODUCTION

The Meandu open-cut mine is owned by Stanwell Corporation Limited (Stanwell) and is located in the Tarong Basin, 180 km north-west of Brisbane, in Queensland's South Burnett region (Figure 1).

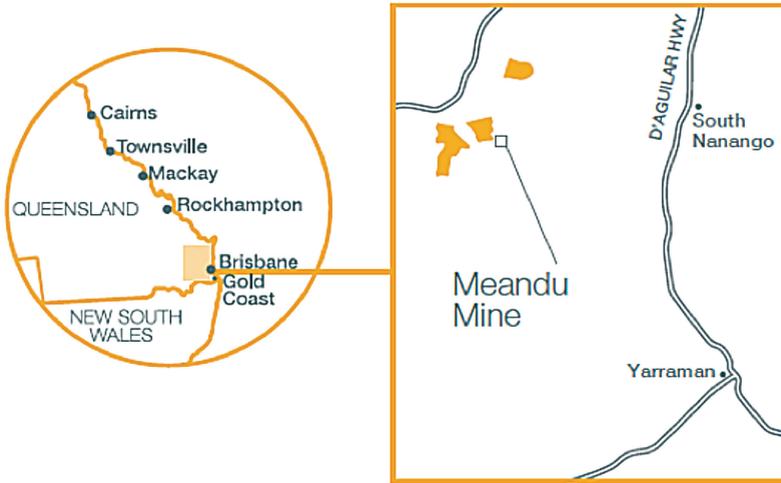


Figure 1 Site Location Map (Stanwell 2016)

Meandu Mine commenced coal deliveries to Tarong Power Station in 1983. The first 350 MW generating unit at the Tarong Power Station was commissioned in early 1984.

The Meandu Coal Preparation Plant (CPP) was commissioned in September 1986. The coal is recovered through open cut mining of three seams and the coal is sized and processed to the Tarong Power Station coal specification. The CPP is designed as two (2) separate modules that are designed to accommodate a nominal 900 t/h each (1800 t/h total). Each module is fed by two (2) conveyors, one of which feeds the coarse coal jig and the other, the small coal jig. The CPP can bypass any of the four (4) jigs as required to meet the product quality specification. Preference is always to bypass one or two of the fine coal jigs first, to minimise tailings, and decrease the product moisture. A conveyor system transfers the dewatered product coal a further 1.2 km to the Tarong Power Station (McRae, 1988).

The Meandu CHPP has operated largely unchanged since its original construction and commissioning, with additional spirals added in the early 1990s. There is no flotation circuit within the CPP, which results in most of the -0.125 mm material fed to the CPP being sent to the thickener for tailings disposal. A conventional tailings dam has been used for tailings disposal since the plant was commissioned in 1986.

The intent of this project is to install a new process that will be able to dispose of the thickened tailings with the other coarse CHPP rejects, by directing the dry tailings onto existing plant conveyors. The dry tailings and other CHPP rejects will report to the existing reject stockpile, for removal by truck and excavator. This will ensure that another large tailings dam will not be required for the remaining life of mine, and that the existing dam can be capped upon reaching its capacity.

This paper discusses the preliminary investigations, concept development, pilot testing, main components of the plant design, and commissioning, as well as the key elements that contributed to the successful outcomes for the project.

### PRELIMINARY INVESTIGATIONS

A range of equipment is available to dewater fine tailings dependant on test work results, capital expenditure and operating costs. Table 1 lists cake moistures produced by devices typically used for ultrafine tailings dewatering.

**Table 1 Typical Moistures of Ultrafine Tailings Dewatering Devices**

Device	Typical Total Moisture Range
Belt Press Filters	35% – 45%
Membrane Filter Press	18% – 35%
Chamber Filter Press	20% – 37%
Deep Cone Thickeners	52% – 65%
Solid Bowl Centrifuges	32% – 48%

Stanwell’s equipment selection was based on the following criteria:

- Ability to be fully automated, without the requirement for extra operations and maintenance personnel.
- High reliability and availability, to match CHPP operation run hours.
- Location close to the CHPP so it can be regularly inspected during operation.
- Maximum solids recovery – the final design intent is to return the clean effluent back to the thickener. This requires good solids recovery to minimise recirculating load.
- Cake that can be mixed in with the coarse rejects from the CHPP.
- Target lowest rate of flocculant consumption.
- Re-use of the existing flocculant dosing system. The current system has excess capacity to that required for the tailings thickener.
- Assessment of up front capital costs and on-going, life of mine, operational costs. This includes a cost comparison between each technology as well as the cost of building new wet tailings dam(s), capping, monitoring and re-habilitation of any new dam(s).
- Designed, installed, maintained and operated as safely as possible in keeping with Stanwell’s zero harm policy.

### SAMPLING AND TESTING

Tailings samples were taken over a period of three weeks and analysed to determine:

- sizing at (mm) 2.0, 1.0, 0.500, 0.350, 0.125, 0.090, 0.063, 0.045, 0.038. Laser sizing was completed on the minus 0.038 mm material,
- ash on each size fraction,

- wt% solids,
- sample density, and
- pH.

Tailings samples were also sent to various equipment suppliers to validate their performance on Meandu tailings using bench scale tests, more specifically flocculant consumption rates, expected throughput capacity, expected cake moisture, expected solids capture rate and required feed conditions.

## EQUIPMENT SELECTION

After completing the preliminary investigations into various dry tailings technologies, Stanwell selected the solid bowl centrifuge technology for dry tailings disposal.

The solid bowl (SoBC) technology was seen to have the following benefits compared to other options for the Meandu tailings:

- High processing capacity. The newer generation of solid bowl centrifuges can process from 35 t/h to 70 t/h of dry solids while still maintaining high g forces.
- Smaller physical footprint required compared to other technologies. This makes it easier to find a suitable installation location without the need for long conveyors or bunkering of the cake product.
- Reasonable anionic flocculant consumption required to form handleable cake with good solids capture, (clear effluent), based on pilot scale test work.
- No use of cationic flocculant.
- Ability to be fully integrated into the existing control system, and be fully automated.
- Relatively simple process that does not require extra operators to run.

However, when comparing solid bowl centrifuges against other technologies, additional factors need to be considered when determining if they are suitable for the intended application. These include:

- Relatively high capital costs.
- Potential high electrical power consumption compared to other options.
- Availability and cost of spares and maintenance items.

### **SOLID BOWL CENTRIFUGE**

Separation in a solid bowl centrifuge (SoBC) takes place in a spinning horizontal cylindrical bowl equipped with a scroll conveyor that typically rotates at a slower speed than the bowl. Slurry, thickener underflow in the Meandu case, is fed into the bowl through a stationary inlet tube and is then accelerated in the feed zone. The solids settle under centrifugal force generated by the high speed rotation of the bowl. The solids that settle (cake) are conveyed to the discharge end of the conical bowl. The clarified liquid and unsettled solids exit at the other end as the effluent. A schematic of the solid bowl centrifuge is shown in Figure 2.

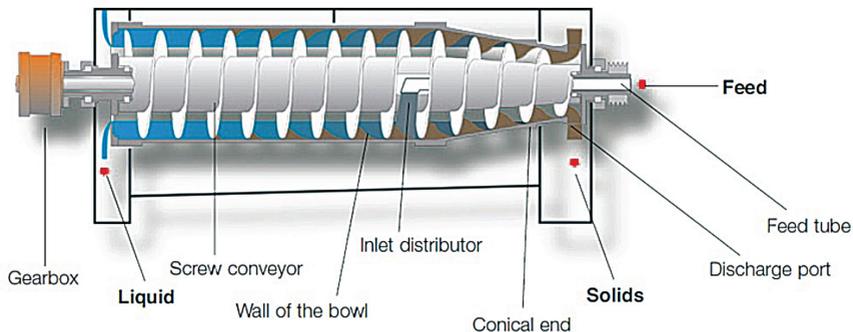


Figure 2 Solid Bowl Centrifuge (Courtesy of Alfa Laval)

Solid bowl centrifuges were installed in Australian coal preparation plants in the 1970s and early 1980s (Mitchell, 1983) but failed to gain acceptance. All Australian installations were replaced by alternate technologies capable of producing lower cake moisture (Koronka, 2009). At the time, solid bowl machines relied on drainage of liquid from the solids particles to generate a high concentration of solids (Madsen, B., 2015): a shallow pond allowed the solids to dewater while being transported through a long drain zone and liquid draining back to the pond (Figure 3). Relying on drainage, a relatively slow process, limits capacity, especially when processing fines particles.

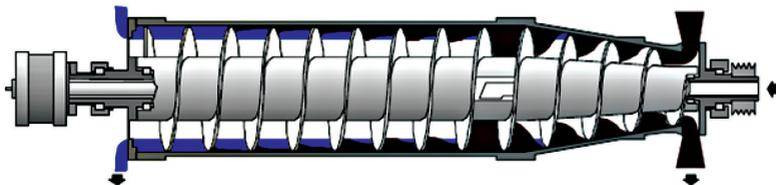


Figure 3 Shallow Pond Geometry (Courtesy of Alfa Laval)

More recent centrifuges are using deeper ponds, where solids are compacted below the liquid surface. The solids overburden is used to compact the solids before being conveyed into the conical section, negating the need of drainage to achieve high solids concentration in the cake (Figure 4). Combined with improvements in the design of major components such as scroll conveyor (Madsen, B., 2015), feed zone (Sutherland, 2009), drives and centrifuge control (Madsen, I., 2015) new machines can deliver higher capacities, a dryer cake and clearer centrate.

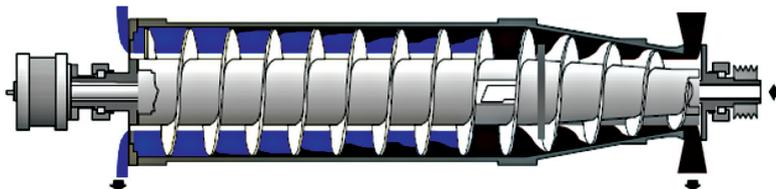


Figure 4 Deep Pond Geometry (Courtesy of Alfa Laval)

Stanwell engaged Sedgman Pty Limited (Sedgman) for the preliminary design and testing of the equipment, based on the selected Alfa Laval P3-10070 solid bowl centrifuge. A pilot scale solid bowl centrifuge was trialled to further confirm its suitability for processing Meandu tailings.

## **PILOT SCALE WORK**

### ***Installation***

Test work was conducted on site using a pilot scale solid bowl centrifuge unit to confirm the suitability of the technology to dewater the thickener underflow. In March 2017, a pilot scale Alfa Laval P2-405 High G-Force solid bowl centrifuge was delivered to the Meandu CHPP for the trial purpose of dewatering the tailings thickener underflow stream (Figure 5). With a 440 mm bowl diameter, the P2-405 unit could deliver equivalent g-force of between 1800 g and 2700 g.



Figure 5 P2-405 Solid Bowl Centrifuge Setup at Meandu CHPP

The unit was fed via a feed pipe connected to the tailings thickener underflow line. Feed flow was controlled via two manual gate valves at the tie-in point and at the feed inlet to the trial unit. Effluent was directed to the CHPP floor and the cake was conveyed via mobile conveyor to the plant product conveyor.

### ***Test Work Programme***

Test work was conducted to determine the cake moisture and effluent quality at a range of process variables. Pond depth, feed rate, bowl speed, conveyor speed and flocculant dosage rate were investigated. The cake moisture and effluent solids concentration were used as the key performance criteria to evaluate the optimal range for the operating variable adjusted during each test. A total of 60 onsite optimisation tests were conducted prior to conducting four audit runs.

The pilot unit ran in the same way that full scale machines are operated using torque control. With torque being linked to the cake properties and amount of solids in the bowl, a torque set-point can be set to target a specific cake moisture. The torque between the bowl and the

scroll conveyor is monitored and the conveyor speed is automatically adjusted to maintain set-point. This is a proven efficient way to handle variation in solids rate and slurry concentration while maintaining cake discharge on moisture target. For example, a low torque setting will increase the conveyor speed and results in higher moisture. Conversely a higher set-point, will decrease conveyor speed and results in lower moisture. It also protects against the potential for over-torque and bogging the centrifuge.

The pond depth and torque trials were conducted at a constant bowl speed of 2680 g equivalent (3300 rpm) as recommended by the OEM. This bowl speed was effective in producing a dry cake and clean effluent at varying feed rates, pond depths and torque settings.

Further trials were conducted by dropping the bowl speed in increments from 3200 rpm (2500 g equivalent) to 3000 rpm (2200 g equivalent) and finally to 2700 rpm (1800 g equivalent). The benefit to reducing the bowl speed is a reduction in power consumption and wear on the rotating elements. However, a decrease in bowl speed below 2700 rpm leads to an increase in cake moisture (Figure 6) and a decrease in effluent clarity. The optimal bowl speed to achieve cake total moistures within the required specification range (35% to 42%) and maintain stable operation was found to be 3300 rpm (2680 g equivalent) for the 440 mm bowl diameter.

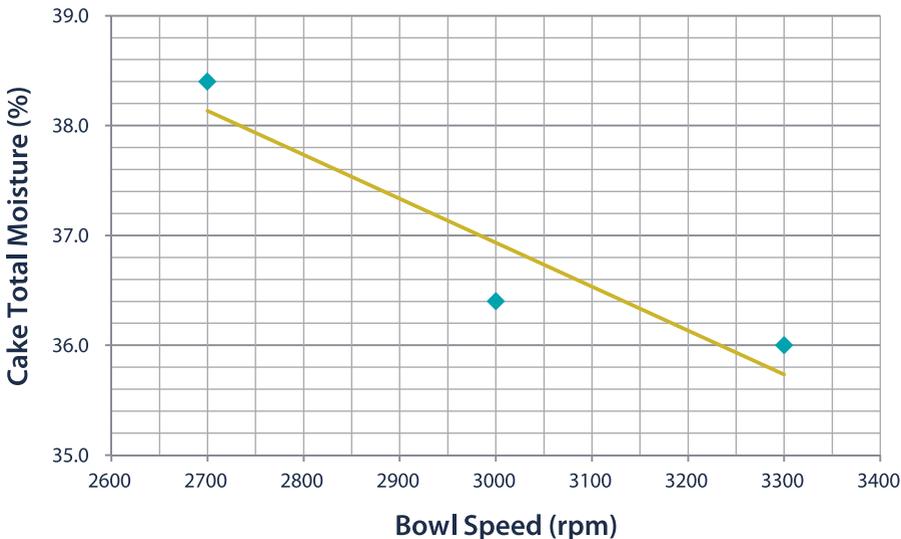


Figure 6 Bowl Speed vs Cake Moisture

**Confirmation Audit Testing**

Based on the test work results, four audits were conducted at varying operating conditions as detailed in Table 2. The aim of the audits was to validate the onsite optimisation test results and assess the mass by size distribution between feed and cake streams.

**Table 2 Summary of Target Audit Operating Parameters**

Parameter	Audit 1	Audit 2	Audit 3	Audit 4
Feed Rate	Constant 5 t/h (ad)			
Torque (kNm)	High	High	High	Low
Bowl Speed (rpm)	3300	3300	2700	3300
Equivalent g	2680	2680	1800	2680
Pond Depth (mm)	Constant	Constant	Constant	Constant
Flocculant Dosage Rate	High	Nominal	Nominal	Nominal

A summary of the audit results is shown in Table 3.

**Table 3 Audit Results**

Stream		Audit 1	Audit 2	Audit 3	Audit 4
Flocculant	Rate	High	Nominal	Nominal	Nominal
Feed	Cw %	30.7	33.9	32.3	30.7
Cake	TM %	36.3	36.5	35.6	36.9
Effluent	Cw %	0.03	0.60	1.20	0.04

Audit 1 ran at a higher flocculant dosage rate at nominal operating conditions. It achieved a clear effluent with 0.03% (w/w) solids (Figure 7), and a dry cake with moisture of 36.3%.

Audit 2 ran at nominal operating conditions, which showed stable operation and maintained a dry cake during the preliminary test work. The torque was kept constant to allow for comparison to Audit 1, and the flocculant dosage rate decreased to a nominal set point. Audit 2 achieved a clear effluent with 0.60% (w/w) solids and a dry cake with total moisture of 36.5%. The effluent clarity decreased from Audit 1 as expected with the decrease in flocculant dosing.

Audit 3 ran at a reduced bowl speed. The torque was kept constant to allow for comparison to Audit 1 and Audit 2, and the bowl speed decreased to 3000 rpm. The effluent clarity decreased significantly with 1.20% (w/w) solids, due to the decrease in bowl speed.

Audit 4 ran at a reduced torque set point. The torque was reduced until the effluent clarity improved. Audit 4 achieved a clear effluent with 0.04% (w/w) solids. The effluent clarity improved from Audit 2, however the cake moisture also increased, as the conveyor differential speed increases to maintain the lower torque set-point, which in terms reduces solids retention.



Figure 7 Audit 1 Effluent Stream

All four audits showed similar feed size distributions and had greater than 96% passing 250  $\mu\text{m}$ , in line with the OEM's.

Audits 1, 2 and 4 all had similar cake size distributions to the feed size distributions with mass recovery greater than 99%. Audit 3 had a coarser cake size distribution than the feed size distribution (Figures 8 and 9), with a lower mass recovery of 97.8%, suggesting a higher fraction of slimes was reporting to the effluent due to the lower bowl speed.

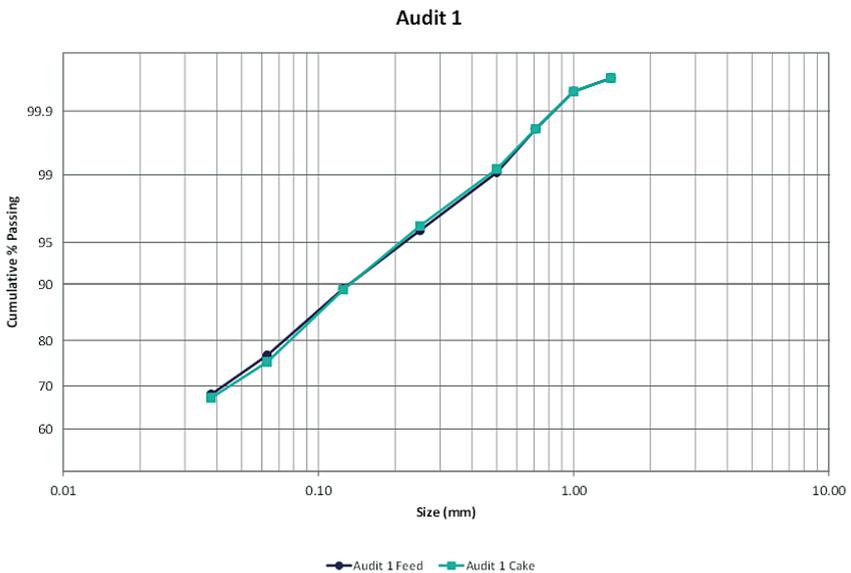


Figure 8 Audit 1 Sizing Results

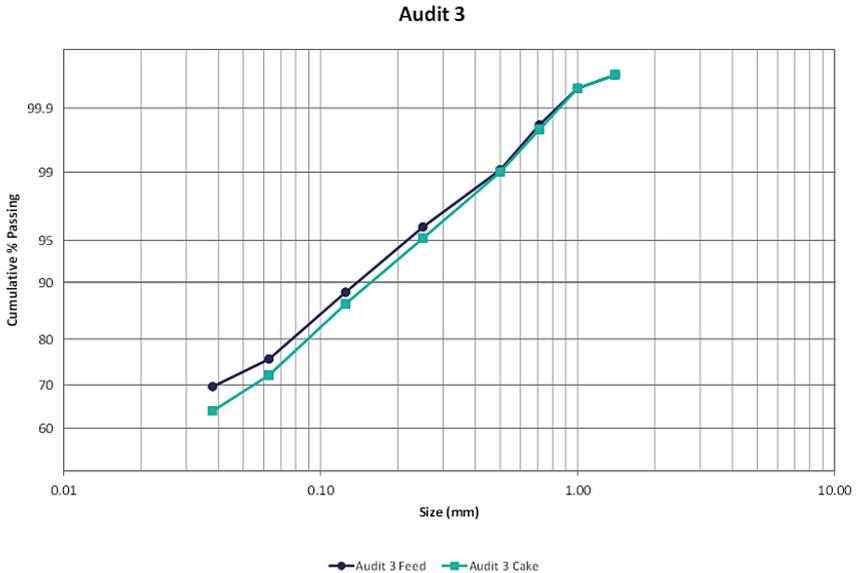


Figure 9 Audit 3 Sizing Results

### *Pilot Testing Conclusions*

Cake moisture decreased with an increase in pond depth until a maximum pond depth was reached.

Cake moisture was found to increase as torque decreased, as the conveyor differential speed increases to maintain the lower torque set-point, which in terms reduces solids retention.

As the feed solids loading increased, the cake moisture increased and mass recovery decreased due to reduced residence time. Running at maximum capacity also requires a higher torque setting to achieve a dry cake with an associated increase in machine wear.

An equivalent 2780 g was found to be effective in producing a dry cake and clean effluent at varying feed rates, pond depths and torque settings.

Flocculant dosing was found to improve effluent clarity. Optimal dosing was determined to be within the range of 300 g/t to 550 g/t. Flocculant dosing test work was conducted using the powder flocculant currently in use onsite.

With sufficient flocculant dosing, mass recoveries greater than 99% were attained while still achieving cake moistures below 39%.

## **CONCEPT DEVELOPMENT**

### **FLWSHEET DEVELOPMENT**

Currently there are two tailings lines to pump thickener underflow to the tailings dam. Each line consists of two pumps in series. One line is DN 250 and the other is DN 200. Both lines are constructed from extra strong steel pipes (Figure 10) and are joined together in a 'Y' piece downstream nearer to the tailings dam. Only one pump set is run at a time.

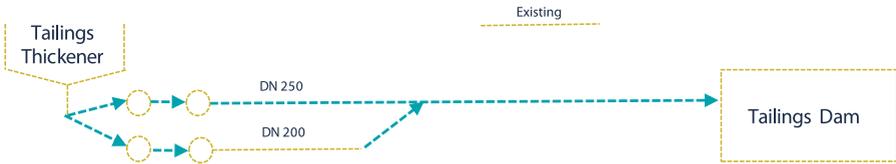


Figure 10 Existing Tailings Disposal

The proposed design will use one pump and the DN 200 line (Figure 11) to transfer thickener underflow to the new SoBC facility. The second thickener DN 250 underflow line will remain as an emergency backup.

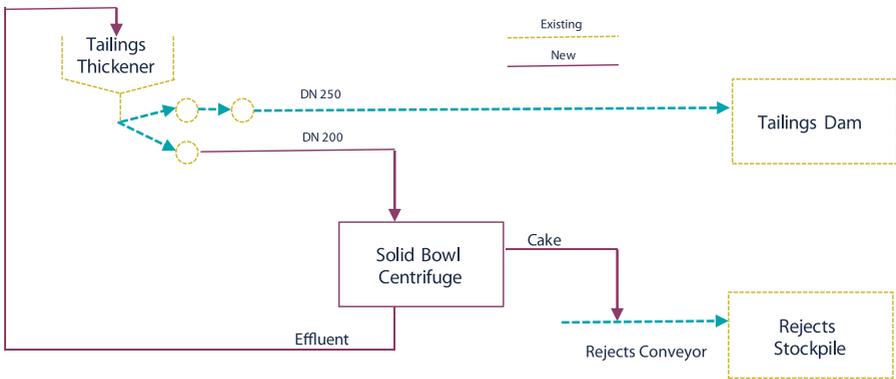


Figure 11 Proposed Dry Tailings Disposal Flowsheet

**LOCATION**

Several locations were considered for the installation of the SoBC facility. Location X (Figure 12) on the southern side of the screening station was determined as the most suitable. It was deemed to have the simplest installation requirements, and therefore the lowest project risk, of the nominated positions for the following reasons:

- It would not impede the screening station maintenance activities.
- It was far enough away from the CHPP to provide an almost greenfield construction site .
- It was close enough to provide routine operator inspections and maintenance.
- There is a single transfer point between loading the SoBC product and the rejects stockpile with the SoBC product being placed on a laden belt, thereby minimising the possibility of fines carry-back on the existing belts.



Figure 12 Selected Location of Solid Bowl Centrifuge Facility

The selected location for the SoBC facility away from the tailings thickener requires the routing of plant feed and effluent pipes as well as services, with thickener underflow pumped to the SoBC feed sump and SoBC effluent pumped back to the thickener feed well as shown in Figure 13 below.

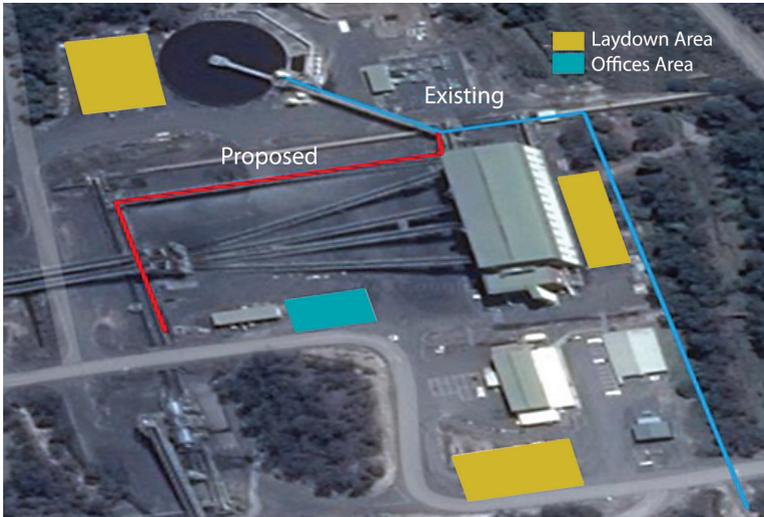


Figure 13 Pipe Route Plan for Selected SoBC Facility Location

4A

### FACILITY LAYOUT

The initial layout for the SoBC facility allowed for direct discharge of the centrifuge cake onto the reject belt to remove a potential transfer point. The two units were at a sufficient height to allow for sumps to be placed under them and for direct discharge of dewatered solids onto the existing rejects conveyor as shown in Figure 14.

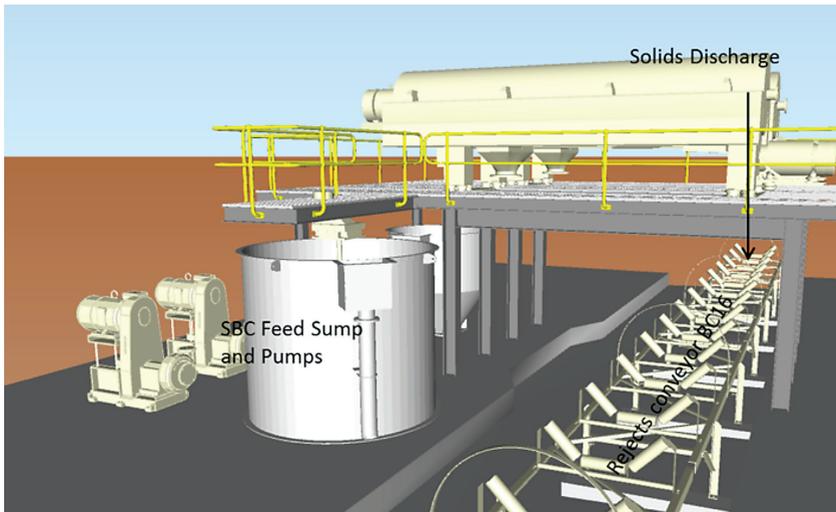


Figure 14 Initial SoBC Facility Layout

On start-up, there is a period of time where the solids bed has not developed sufficiently to discharge solids only and slurry may be discharged onto the rejects belt causing damming and spillage. In addition, a large volume of flushing water reports to the product discharge during the flushing cycle and then onto the rejects belt.

As a result the direct loading option was redesigned to incorporate a transfer conveyor to collect the SoBC solids discharge and transfer it to the rejects conveyor (Figure 15).



Figure 15 SoBC Layout with Transfer Conveyor

## PROJECT EXECUTION

Following the concept development phase, Stanwell engaged Sedgman for the design, supply, construction, installation and commissioning of the equipment with the following objectives:

- Provide a thickener underflow dewatering facility to replace the current method of tailings disposal, with the facility designed to operate independently of the CPP but in conjunction with the thickener.
- Deposit the dewatered tailings onto the CPP rejects conveyor to allow for combined disposal of coarse and fine tailings.
- Return the clarified SoBC effluent back to the thickener feed.

### PROJECT EXECUTION MODEL

Execution of the project was carried out under an EPC model with Stanwell procuring the solid bowl centrifuge and Sedgman performing the detailed design, procurement, management of construction activities and sub-contractors, and commissioning. While Sedgman was responsible for the centrifuge feed, cake handling, effluent return and flocculant supply, Alfa Laval was accountable for the centrifuge performance.

Stanwell successfully fully managed the installation of the pipework interconnecting the tailings thickener with the new solid bowl centrifuge facility.

### SCHEDULE

Considering the Alfa Laval P3-10070 delivery of 10 months, Stanwell pre ordered one machine in late 2016 prior to the awarding of the EPC contract, allowing for a delivery in mid 2017. A second machine was ordered early 2017 and delivered to site mid December 2017. As a result, the project schedule incorporated two steps of commissioning.

Contract was awarded mid May 2017 with a scheduled feed-on to the centrifuges mid-January 2018. The project was accelerated which allowed the first centrifuge to be wet commissioned late November 2017 with successful acceptance testing late in December 2017.

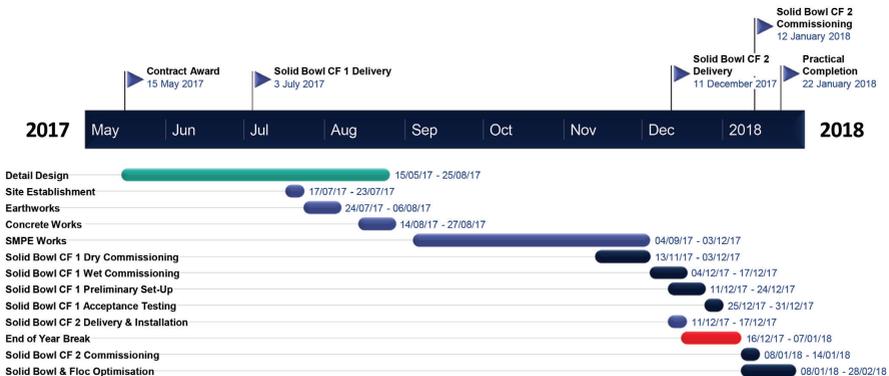


Figure 16 Project Schedule

### CONSTRUCTION

Concrete was poured mid-August, first steel erected mid-September and the first solid bowl centrifuge was lifted in place early October 2017 (Figure 17).



Figure 17 Solid Bowl Centrifuge Installation

Ease of construction was facilitated by the design which maximised off-site fabrication, such as welded floors and fully assembled conveyor frames. Nil errors were recorded on fabricated steel. The MCC was fully containerised and tested off-site prior delivery (Figure 18). The use of electronic tablets on site helped the SMP and electrical contractors visualise the design, reducing the number of queries back to the design office, improving installation efficiency. Zero LTIs were recorded during the project (construction and commissioning).



Figure 18 Containerised MCC and Fully Installed SoBC Facility

## COMMISSIONING

Once the piping and electrical installation was complete, commissioning commenced and was completed without incident. Pre and wet commissioning of the first solid bowl centrifuge was completed in one week. Thickener underflow was diverted to the first solid bowl centrifuge in the second last week of November 2017. Following wet commissioning, the centrifuge operation was initially set-up by Alfa Laval to allow successful acceptance testing late in December 2017.

While cake moistures below 39% and clear effluent were achieved, further optimisation of flocculation addition and operation of the Alfa Laval P3-10070 are being progressed with the aim of successful performance testing being achieved.

## CONCLUSIONS

The successful change to dry tailings disposal at the Meandu CHPP was made possible by a thorough assessment of the selected solid bowl centrifuge technology via laboratory and pilot scale test work. The execution requirement was met ahead of schedule by implementing a specific procurement and construction strategy. While further optimisation work on flocculant addition and centrifuge settings are still on-going, the resulting equipment performance achieved has met expectations both from a cake moisture, effluent clarity and operability perspective.

## ACKNOWLEDGMENTS

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