APPENDIX C

Dewatering options report - comparison of options for tailings dewatering

Dewatering Options Report

Cobbora Holding Company

Comparison of Options for Tailings Dewatering

Client Document Number: ***C0203-QCC-MEC-0020***
Project Document Number: ***COB01-J15-N-REP-G-002***

Date: 31st January 2013 Revision: 3

QCC Resources Pty Ltd

3 Alfred Close
East Maitland NSW
Australia 2323

Tel: +61 2 4937 9900
Fax: +61 2 4937 9990

ABN 56 084 344 070

Disclaimer

This report has been prepared by QCC Resources for Cobbora Holding Company Pty Limited. QCC Resources accepts no liability or responsibility whatsoever for, or in respect of any use of, or reliance upon this report by a third party.

Approvals

Approval / Signatures			
Action	**Name**	**Role**	**Signature**
Prepared by:	CT	Senior Process Engineer	
Reviewed by:	RS	Chief Engineer	
Approved by:	BG	Study Manager	

Revision History					
Rev	**Date**	**Description**	**Prepared**	**Reviewed**	**Approved**
0	10/11/2012	For Approval	CT	RS	BG
1	10/12/2012	Approved including Client comments	CT	RS	BG
2	9/1/2013	General Revision	CT	RS	BG
3	31/1/2013	Issued for Publication	CT	RS	BG

Table of Contents

1. Executive summary 5
2. Background 7
2.1 Traditional dewatering practice 7
2.2 Dewatering principles 9
2.3 Cobbora tailings requirements 11
3. Technology comparison 12
3.1 High rate thickening – base case 14
3.1.1 Description 14
3.2 Paste thickening – direct discharge to reject belt 15
3.2.1 Description 15
3.2.2 Paste thickening block flow sheet 17
3.3 Belt press filters 18
3.3.1 Description 18
3.3.2 Belt press block flow sheet 20
3.4 Pressure filters 21
3.4.1 Description 21
3.4.2 Pressure filter block flow sheet 23
3.5 Solid bowl centrifuges 24
3.5.1 Description 24
3.5.2 Block flow sheet 25
3.6 Water recycling 26
4. Capital costs 27
4.1 Cost Comparison 27
4.1.1 Base case dewatering – high rate thickening and disposal to tailings dams 27
4.1.2 Alternative dewatering options capital cost 27
4.1.3 Risk mitigation costs 28
4.1.4 Additional capital – other affected systems 29
4.1.5 Capital cost comparison – all factors 29
4.2 Assumptions 30
4.3 Exclusions 30
5. Operating costs 31
6. Life of mine costs 33
7. Discussion 34
8. Conclusions and recommendation 36
Appendix 1 – Equipment lists 37

Appendix 2 – SWOT analysis 53

1. Executive summary

The Cobbora coal project is proposing to use tailings storage emplacements to store its ultrafine reject material.

This report investigates alternative dewatering methods that could replace a tailings emplacement. It considers alternative technologies between fixed battery limits. It does not consider all the implications or impacts on surrounding systems; but even so it provides an indication of the process performance ranking of alternative dewatering process systems together with their capital and operating costs.

The base case dewatering method for Cobbora will thicken the ultrafine reject in a high rate thickener to a consistency of between 30% and 35% solids and pump the resultant tailings slurry to tailings storage dams. Two out-of-pit tailings dams are intended for storage for around the first five years of operation followed by storage in-pit in redundant open cut mine ramps.

Five different alternatives for tailings dewatering were compared against a set of dewatering criteria. As each of these dewatering systems is fed with thickener underflow, the initial high rate thickening stage is a cost common to the base proposal and all alternative technologies. Capital costs in this report include this pre-thickening stage.

Secondary flocculation has become popular with coal operations across the Australian coal industry. It has the second least capital cost but moderately high operating costs. The storage volume per unit area will be greater than a tailings dam alone but the extent will be a function of the landscape (i.e. topography). There is some risk associated with changing tailings volumes and water release at the tailings emplacement that does not occur with the other technologies considered in this report.

Paste thickening is a recently introduced technology to coal tailings with two sites operating in Australia. Paste thickening can produce a conveyable paste at 50–55% solids but is at times subject to control risks with changes in chemistry of tailings. The paste thickening system can be applied to treat the full tonnage of anticipated tailings solids but is probably best used with a small tailings emplacement to improve overall disposal reliability.

Belt press filters have been used in the coal industry since the early 1980s. There are over 25 sites that have installed belt press filters and some of them remain in use. Belt press filters have a relatively low unit throughput per machine, are cost-intensive to operate and require dedicated staff to ensure their smooth operation.

Pressure filters are widely used in the mineral and chemical industries, but only one coal mine in the Hunter Valley has installed them to treat coal tailings in Australia. Their overall capacity depends a lot on the nature and quantity of clays. The reference installation in the Hunter is considered to have failed because the units selected were not large enough. While pressure filters can deliver the driest tailings cake, it is the most expensive technology.

Solid bowl centrifuges were popular in the 1980s and competed directly with belt press filters for tailings dewatering. From the early 1990s they stopped being used because they could not cope with increasing production rates. In the last few years a high capacity solid bowl centrifuge has been developed that is worthy of consideration. A solid bowl centrifuge plant for Cobbora has the advantage of requiring only three machines at start-up and no additional labour to operate.

The start-up cost, annual power consumption and dewatering benefit for each dewatering option are shown in Table 1.1 below.

Table 1.1 Dewatering option costs and benefits at nominally 200 tph

Option	Description	Cake solids (%w/w)(1)	Power consumed MW/year	Capital cost ($M) (2)	Operating cost ($M/year)
Base	Thicken + emplacement	35	3.25	35.0	0.8
1	Thicken + secondary flocculation + emplacement	55	3.60	39.0	3.4
2	Thicken + paste thickener + emplacement backup	55	2.91	62.5	6.4
3	Thicken + belt press filter + emplacement backup	60	4.15	63.5	9.2
4	Thicken + pressure filter + emplacement backup	65	2.21	104.8	5.6
5	Thicken + screen bowl centrifuge + emplacement backup	65	14.26	69.3	6.4

(1) Initial without consolidation
(2) Expenditure required at day one of CPP production and are based on systems sized to cater for the initial tailings production rate anticipated in the first four years of mine operation storage

The report excludes the costs/benefits of each system that may apply to the period outside of the out-of-pit storages and does not consider any effects on the freshwater, groundwater or surface water site water requirements that may arise from using an alternative system.

It is recommended the Cobbora project adopt the base case thickening design with high rate thickening and discharge to tailings emplacements as the economic alternative. The initial capital cost of the system is the lowest from the options investigated with the lowest operating cost. The life of mine cost of the system is the lowest even when tailings emplacement rehabilitation is accounted for.

The base case thickening technology is also the simplest to operate, has less technical risk and is less sensitive to rising input costs for electricity and labour into the future.

The environmental benefit of additional water recovery from mechanical dewatering is offset by high operationally costs, power usage and the need for an emplacement facility as a backup.

2. Background

2.1 Traditional dewatering practice

The Cobbora Coal project includes the traditional concept of disposal of tailings slurry to emplacement areas where the solids proportion of the slurry consolidates over time and some of the released water at the dam is recovered and recycled for reuse in the coal washing circuits.

This is typically how most coal preparation plants in Australia and overseas dispose of their tailings. But there is a growing interest in alternative technologies that can deliver improved water recovery, smaller footprint of tailings disposal areas, better rehabilitation opportunities or a combination of these things.

These alternative technologies have been looked at as a single tailings management solution, or as something added to traditional tailings dam disposal.

The key considerations in selecting the components of a tailings disposal system would include, among other things:

- available land area for disposal in either single or multiple disposal locations;
- topography of selected sites for containment volumes and sensitivity to holding capacity of the life of mine;
- considerations of storage volume and consolidation time with respect to the normally desirable progressive rehabilitation of tailings disposal sites;
- the opportunity to dispose of fine reject with coarse reject, which may influence the rate of consolidation and thereby present an opportunity for faster rehabilitation;
- the selection of sites(s) to avoid sterilising future coal reserves;
- remoteness of the disposal site;
- the impact of future expansion or containment;
- the extent to which water recovery is required (at the plant or dam site) and whether maximising the water recovery or the ability to dispose of excess water is the primary aim — and whether this aim is required across the life of mine;
- the effect of high recycle water rates on accumulation of dissolved salts and effects of corrosion;
- capital costs of the entire system;
- operating costs of the entire system;
- reliability and stability of the system, particularly the tailings chemistry, particle sizing and tailings generation rates; and
- stability of spoil dump that includes co-disposal.

The primary objective of this report is to present a comparison of the traditional tailings dam disposal technique with other alternative technologies that are in use or that have been used in the past. Blue sky or emerging technologies have not been considered.

Section 2.2 describes the historical application of each technology, the main reasons for adopting these systems and a qualitative ranking on expected performance based on the physics applied to the dewatering process generally.

Section 2.3 states the base process criteria to compare each technology.

Section 3 compares each dewatering option against the comparison criteria. A strengths, weaknesses, opportunities and threats (SWOT) analysis of the technologies is included in Appendix 2.

Sections 3.1 to 3.5 describe the mechanics of each system supported by a block flow sheet. The equipment list for each system is provided in Appendix 1. Section 3.6 describes the estimated water recovered for recycling to the CPP washing process over the life of mine.

Section 4 provides an order of magnitude capital cost estimate comparison for each system and gives a basis of estimate. This section also has a table showing an uncosted description of other related equipment, systems and services that were not part of the cost estimate but even so would require an upgrade.

Section 5 provides a rough operating cost comparison between the technology alternatives with an emphasis on power, flocculant and staffing levels. Operating costs are based on spending over the initial five years. Some commentary is provided on the extent of spare parts and maintenance intensity.

Section 6 provides a comparison of indicative life of mine net present value (NPV) values for capital and operating costs.

2.2 Dewatering principles

The physics of tailings dewatering are well understood and equations describing the dewatering process have been developed that all include the following primary variables:

a) Pressure applied.

The higher the pressure applied the better the dewatering.

In the base case adopting normal thickening, this pressure is around 5 kPa.
For paste thickeners a gravitational force of 50 kPa to 70 kPa is applied.

In the case of belt press filters, pressure is applied gradually through a series of rolls of diminishing diameter (increasing pressure). Typical final pressures applied in final nip rollers may amount to 200–300 kPa.

In the case of pressure filtration the pressure is applied across the filter cloth to typically 800 kPa.

For solid bowl centrifuges, a centrifugal force of 380 G to 1500 G is applied.

b) Shear

Application of pressure alone will not necessarily generate a high solids content product. Pressure releases the water from the cake but some degree of shear, which is the relative movement between the dewatered particles, is required so the released water can be transported to a free surface.

In the case of paste thickeners, the action of the rake ensures a slow turnover of material at the base, channels are formed in the slurry for water release.

For belt press filters, the shear is induced through the action of the differential speed of the sandwich belts around the rollers.

In the case of pressure filtration, very little shear is involved in the actual dewatering process.

For solid bowl centrifuges, the shear is a result of the action of the transporting scroll in the machine running at a differential speed to the main bowl.

c) Flocculation

Flocculation is a process where the addition of a chemical promotes clumping of small particles to larger ones. Larger particles settle faster.
Paste thickening requires flocculation to assist in separating water from the solids..

Belt press filters require flocculation to prevent the cloths getting bound up with fine particles.

Pressure filtration does not use flocculant and solid bowl centrifuges benefit from flocculation by increasing initial particle size.

d) Time

Time is required in any dewatering process to allow the pressure and shear elements to drive the solids content in the product to equilibrium. This is never reached, but increased retention time in any device under pressure will result in a drier product.

Solids retention times in paste thickeners would be typically 8–12 hours, pressure filters around 40 minute cycles, belt presses typically 2 minutes and centrifuges less than a minute.

The system comparisons presented in this report include:

high rate thickening plus tailings storage emplacements – the base case;

secondary flocculation (sometimes called end of pipe flocculation) plus tailings storage emplacements;

paste thickening (sometimes known as deep cone thickening) plus tailings storage emplacements;

belt press filtration plus backup tailings dam;

pressure filtration plus backup tailings emplacement — in earlier times known as plate and frame filter presses and developed to be better known as chamber filters or a hybrid technology called membrane filters; and

solid bowl centrifuges plus backup tailings dam.

In Table 2.1 a qualitative rating is applied through engineering experience to each system to describe the importance of each physics element to the resultant dewatered product. The ratings are then added up to provide an indication of the system ranking.

The lower the ranking the drier the resultant dewatered product.

Table 2.1 Qualitative performance of dewatering technologies

SYSTEM	PRESSURE	SHEAR	FLOCCULATION	TIME	CUMULATIVE RATING	RANKING
High rate thickening (base case)	1	2	2	5	10	6
Secondary flocculation	2	2	6	5	15	5
Paste thickener	3	2	4	6	15	4
Belt press filtration	4	4	6	2	16	3
Pressure filtration	9	1	2	4	16	2
Solid bowl centrifuge	10	8	3	1	23	1

This ranking is reflected in actual dewatering practice. High rate thickening produces a slurry — which is not classed as a cake. The other alternatives with the highest tailings cake moistures are secondary flocculation or paste thickening and the lowest tailings cake moistures are the pressure filtration and centrifuge options.

The most significant factor influencing the process outcome is the pressure applied. Not surprisingly, the capital cost also rises as the applied pressure increases.

2.3 Cobbora tailings requirements

The proposed baseline technology for the Cobbora tailings dewatering is a single 40-m diameter high rate thickener to treat the combined ultrafine reject from both operating CPP modules. The resultant 35% solids underflow would be pumped to multiple tailings storage emplacements.

To establish a common basis of comparison, each of the dewatering alternatives uses a common feed input.

The input basis is equivalent to the maximum tailings generated from a 2000 tph run of mine (ROM) coal twin module coal preparation plant CPP with the addition of a 10% design allowance.

Maximum tailings from design envelope: 9% ROM	= 180 tph
Design allowance of 10%	= 18 tph
Loading input for comparison of systems	= 200 tph

The input to each dewatering system is via the underflow of the proposed tailings thickener delivering slurry at 35% w/w solids.

3. Technology comparison

Each of the dewatering technologies has been compared against a comparison criteria set that encompasses: sizing requirements, process sensitivity, external effects and output quality.

Table 3.1 summarises the comparison.

	Criteria Comparison	DEWATERING SYSTEM					
		Base case High Rate Thickener + Tails emplacements	High Rate Thickener + Secondary Flocculation + Tailings emplacements	Paste Thickening+ Tailings emplacement	Pressure Filtration + Tailings emplacement	Belt Press Filtration + Tailings emplacement	Solid Bowl Centrifuges + Tailings emplacement
QTY & SIZES	Number of Operating Units for Design Throughput	One	One System	One Thickener	Six	Eight	Two
	Number of Standby Units	Nil	Nil	Nil	Two	Two	One
	Size of Representative Unit	40 m diameter HRT	N/A	30 m diameter x 8m sidewall	2m x 2m x 170 plates-30 m long	3m wide with drainage zone,and pressure rolls, 3.5 m long	1400 mm dia x 5.6 m long
	Nominal Capacity / Unit	200dry tph each	200dry tph each	200dry tph each	40 dry tph each	20 - 25 dry tph each	100 dry tph each
OUTPUT QUALITY	Typical Solids Content	30- 35% w/w	50-55% w/w	50-55 % w/w	65-70 % w/w	55-65 % w/w	65-70 % w/w
EXTERNAL EFFECTS	External backup Equipment / Systems	Nil	Nil	Backup Tailings emplacement and tails pump/pipeline	Standby machines included / backup Tailings emplacement and tails pump /pipeline	Standby machines included / backup Tailings emplacement and tails pump /pipeline	Standby machines included / backup Tailings emplacement and tails pump /pipeline
	Effect on final disposal	Requires long period of time before emplacement rehabilitation	Increases stackable slope in emplacement, reduces footprint	Higher stackable slope than Secondary Floc. Limited by geotechnical stability	Higher stackable slope than Secondary Floc. Limited by geotechnical stability	Higher stackable slope than Secondary Floc. Limited by geotechnical stability	Higher stackable slope than Secondary Floc. Limited by geotechnical stability
	Co dispose with coarse	No	No	Yes. Conveyed by truck	Yes. Conveyed by truck	Yes. Conveyed by truck	Yes. Conveyed by truck
	Water Recovery	Extra pumping at tails emplacement site for return water	Increased recovery but at remote site. Requires treatment with cat floc and pumped return to CPP	Water recovered at CPP with very limited return water from backup emplacement	Water recovered at CPP with very limited return water from backup emplacement	Water recovered at CPP with very limited return water from backup emplacement	Water recovered at CPP with very limited return water from backup emplacement
	Effect on Future Storage capacity	Base case includes out of pit and in pit emplacements	Delays emplacement fill rate or emplacement raising but dependant on slope actually achieved	Reduces requirement for emplacement storage to emergencies and process upset periods	Reduces requirement for emplacement storage to emergencies and process upset periods	Reduces requirement for emplacement storage to emergencies and process upset periods	Reduces requirement for emplacement storage to emergencies and process upset periods

PROCESS SENSITIVITY	Variation in Dry tonnage Throughput	Largely immune , Design caters for wide operating envelope	Largely immune , Design caters for wide operating envelope	Higher rates result in lower moisture & conveyability problems	On its own, only affects the number of operating machines	On its own, only affects the number of operating machines	On its own, only affects the number of operating machines but due to lower number of machines, the performance may be affected by turndown ratio
	Variation in Slurry Feed Density	Manageable risk through auto control	Flocculation efficiency affected by lower density - may not achieve emplacement slope in practice	Not affected within normal range	Throughput increased with increased density ie higher unit capacity	Higher density means lower volumetric throughput and higher dewatering retention times therefore improved performance	Higher density means lower volumetric throughput and higher dewatering retention times therefore improved performance
	Variation in Particle Size	Finer particles result in decreased performance, higher floc consumption	Finer particles result in decreased performance, higher floc consumption	Finer particles result in decreased performance, higher floc consumption	Finer particles result in decreased performance, higher floc consumption	Finer particles result in decreased performance, higher floc consumption	Finer particles result in decreased performance, higher floc consumption
	Variation in Chemistry (pH, Clay type)	pH6-9 not affected, High expanding clays drop throughput and affect emplacement slope angles	pH6-9 not affected, High expanding clays drop throughput and affect emplacement slope angles	High levels or clay and expandable clay mineralogy will result in decreased capacity and/or increased flocculant consumption	High levels or clay and expandable clay mineralogy will result in decreased capacity	High levels or clay and expandable clay mineralogy will result in decreased capacity and/or increased flocculant consumption	High levels or clay and expandable clay mineralogy will result in decreased capacity and/or increased flocculant consumption
OPERATING COSTS	Anionic Floc Consumption	100g/tonne	250-350g/tonne	120-180 g/tonne	Nil	400 g/tonne	200 g/tonne
	Cationic Floc Consumption	Nil	60ppm on return water volumetric rate	Nil	Nil	200 g/tonne	Nil
	Power Consumption Connected	75kW (at remote site)	300kW (at remote site)	810kW installed at CHPP	1100kW installed at CHPP	480kW installed at CHPP	4500kW installed at CHPP
	Power Consumption absorbed (not incl'd prethickening)	50kW	200kW	420kW	600 kW	320kW	2060kW
	Manning Levels	Nil extra (all at CHPP)	Nil extra requires daily drive by check	Nil Extra	Additional Operator	Additional Operator	Nil

3.1 High rate thickening – base case

3.1.1 Description

The ultrafine reject together with a large proportion of the coal preparation plant circulating water stream is directed to a single 40-m high rate thickener (HRT). Note an additional thickener will be required when production increases beyond 2000tph ROM.

The thickener feed is dosed with an anionic flocculant, which promotes fine particles to collect into larger clumps (aggregate) and hence accelerates settling rates and provides a clean overflow. Clarified water is returned to the process.

The settled underflow, which is typically 30% to 35% weight water to weight) (w/w) solids is pumped by a two-stage pumping system to the tailings dam(s).

In the case of the alternative dewatering technologies, the tailings pumps deliver to the input of that technology.The primary thickening stage is thus common to all dewatering options considered in this report.

Figure 3.1 Example high rate thickener

3.2 Paste thickening – direct discharge to reject belt

3.2.1 Description

Paste thickeners were developed in the aluminium industry in the 1970s and the majority of applications are for handling alumina red mud. The technology has been increasingly applied to other mineral processes and coal over the last 15 years.

The usual description of a paste is a slurry that does not bleed water on standing — most mineral processing applications transfer the paste via pipeline still in a slurry form (albeit through the use of positive displacement pumps due to the high pipeline frictional losses generated).

An extension of this technology (although not widely used) is to thicken the underflow to a consistency that can be transported on conveyor — with the aid of coarse reject — as a mixture that can be handled in chutes, bins and in trucks.

One Hunter Valley coal mine has used this approach to process a proportion of the site tailings generated. A tailings storage emplacement area is used with secondary flocculation to treat the remainder.

A smaller paste thickener at a Queensland mine operation also uses a paste thickener but the product generated there is pumped to its final location.

Figure 3.2 Discharging paste thickener material to conveyor

Paste thickeners are an extension of the normal thickening process using a flocculant to bind fine particles together. The flocculated particles settle to the base of the thickener and are removed via pumps. In paste thickening, the side walls of the vessel are typically between 8 m and 12 m high. This allows a bed of solids to accumulate over a greater height.

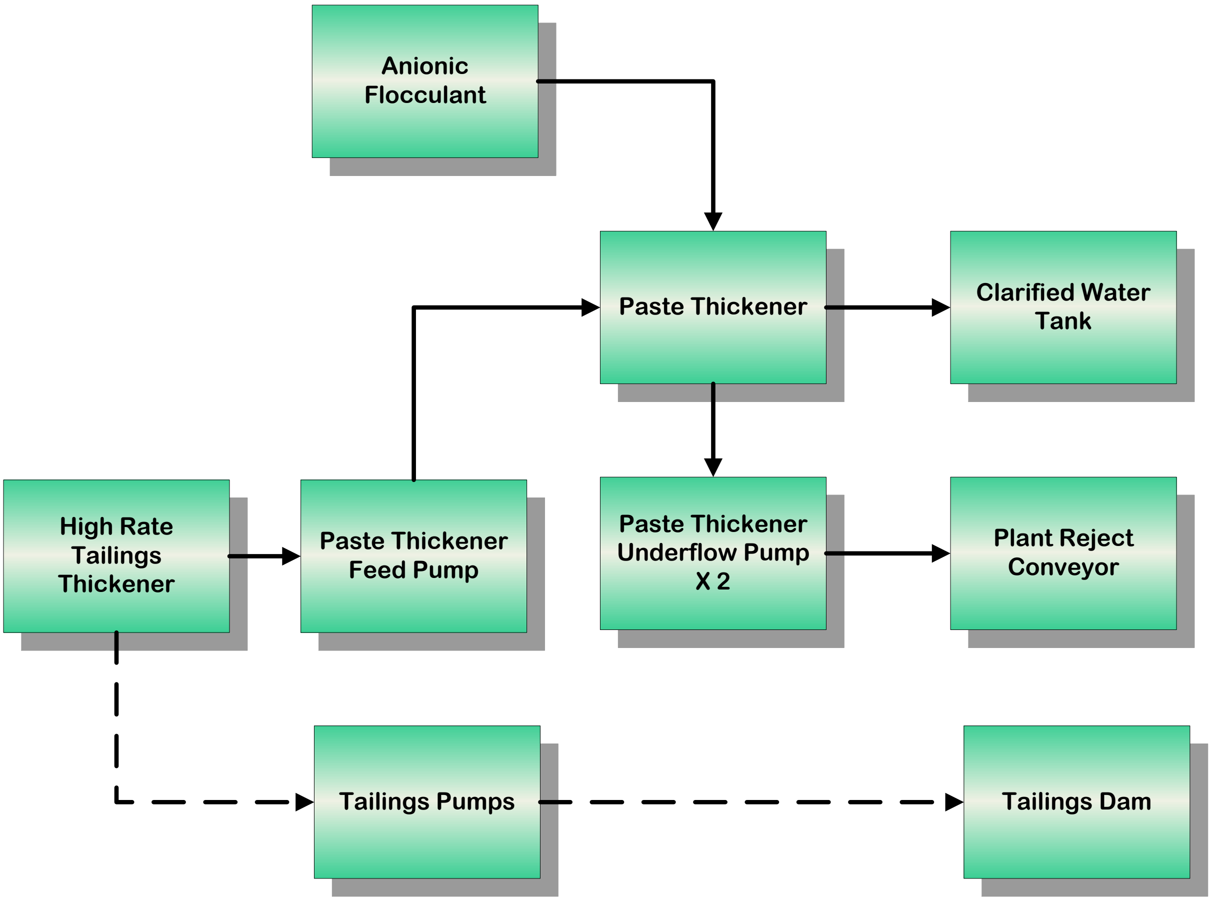
The additional bed depth generated applies pressure to the layers in the lower regions of the thickener, thereby squeezing more water from the slurry.

A coal paste thickener can typically generate an underflow density of between 50 and 55% solids w/w— a range that is transportable by conveyor.

While the paste thickening process is generally cheaper than mechanical dewatering, the lower underflow density requires a minimum amount of coarse reject so that materials can be handled through chutes and bins, and in particular during mine truck transport to final emplacement.

Due to operational challenges experienced with these units it is not recommended to use a paste thickener without a backup tailings emplacement . The tailings emplacement allows slurry to be bypassed during process upsets. A tailings storage emplacement has been allowed in the costing comparison.

3.2.2 Paste thickening block flow sheet



3.3 Belt press filters

3.3.1 Description

Belt press filters (BPF) have been used to mechanically dewater tailings at a variety of sites. The belt press filter relies on overlapping cloths squeezing the tailings through rolls to remove the water. Flocculants play a large part in the dewatering process and are essential to get acceptable results from a belt press filter.

Figure 3.3 Belt press filter

Feed is fed to the top level of the filter where the bulk of the water will drain from the solids and form a cake (see Figure 3.5 for cake formation). Another cloth is then placed on top of the cake to form a 'sandwich' phase to further squeeze water from the cake. In the final stage the material traverses the roller sections of the belt press filter and then the dewatered cake discharges onto the reject conveyor (see Figure 3.5).

Figure 3.4 Feed section of belt press filter

Figure 3.5 Belt press filter discharge

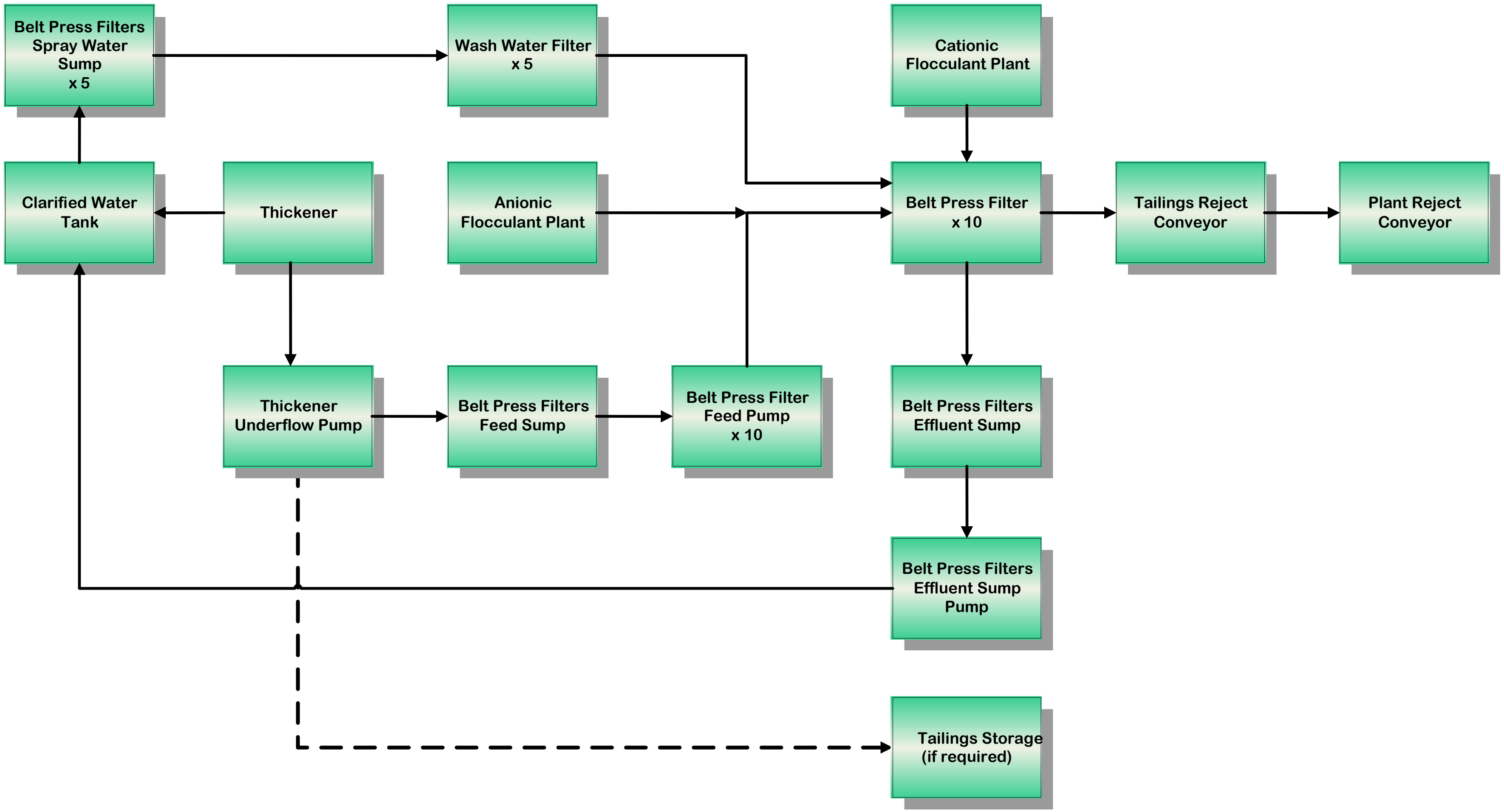
The belt press filter will dewater tailings with a discharge moisture of (roughly) 35–45%. While belt presses are widely used, they are a high maintenance and operating cost item. The cloths need to be changed (on average) every 2,000 hours and the cloth must be monitored during operation for any creases, folds or tears that would mean a cloth must be changed before the 2,000 hours.

Belt press filters depend as heavily on chemicals as the mechanical aspect of the machine. The filters require (roughly) 400 g/t (BPF feed) of anionic flocculant and 200 g/t (BPF feed) of cationic flocculant. These numbers depend on the type of clay present at site and if there are plans to mine multiple seams then the flocculant rates (and hence the effectiveness of the belt press filters) can vary greatly. It is possible the filter's throughput could even halve depending on the nature of the clay in the plant feed. Also belt press filters do not perform as well when treating weathered material. To mitigate this risk, a tailings dam has been allowed in the capital cost to cater for process upsets or insufficient capacity.

Ten, belt press filters each 3 m wide would be required for the Cobbora plant to cater for the initial tailings production rate anticipated in the first four years. Thickener underflow would be pumped to a common belt press filter feed sump. Each filter would have a dedicated feed pump that is controlled by a flow meter before the filter (so that each filter is fed equally without flooding). The effluent from each filter would be collected in a common sump and pumped to the clarified water tank. The cake would discharge onto a dedicated tailings reject conveyor, which in turn discharges onto the reject conveyor.

The belt press filters would require dedicated anionic and cationic plants due to the quantities of flocculant used. Water to wash the rolls and cloth is also required, wash water will be supplied from a dedicated sump fed from a clear water source. Five wash-water pumps would be required (one per pair of filters) to supply the wash water.

3.3.2 Belt press block flow sheet



3.4 Pressure filters

3.4.1 Description

Pressure filters have been used to dewater coal tailings with varying results. They are large machines that operate by pressing together a number of plates with a cloth and membrane and pumping the feed in. Pressure filters rely purely on mechanical and hydraulic pressure to dewater the tailings- no chemical or flocculant is required.

Figure 3.6 McLanahan pressure filter

The pressure filter is a batch process with a processing cycle that consists of three distinct phases: a feed phase, drying phase and discharge phase. During the feed phase, the plates are compressed against each other and the slurry is pumped in. After the machine has reached its capacity, feed is switched off and the machine goes through its drying phase. During the drying phase water is added to the membranes, which causes them to inflate and squeeze the water through the cloth, leaving a dry cake. During the first two stages the gates under the plate discharge are in the closed position, sending any material to the effluent; during discharge these gates open allowing material to discharge onto the filter's cake conveyor. Due to the large footprint of the pressure filters, the discharge phase can take a long time (entire cycle can vary from 30 to 45 minutes); during the discharge phase a pneumatic ram separates out the plates allowing a dried product (see Figure 3.7) to discharge onto a conveyor.

Figure 3.7 Pressure filter discharge

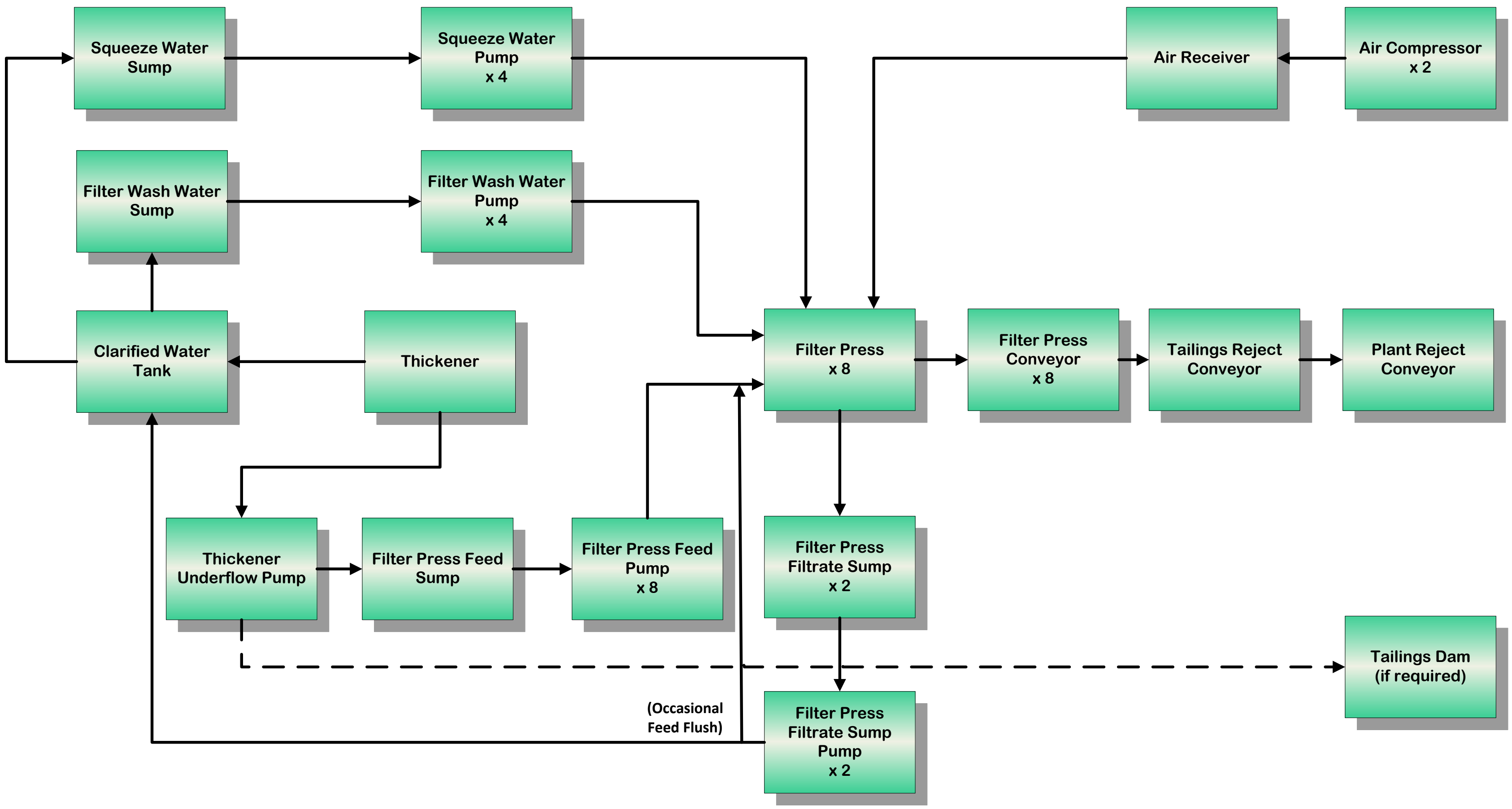
As well as there being a large capital cost, there is also a continual operating cost in the cloth for the filters. Each cloth will last between 2000 to 4000 hours at a replacement cost of $250 a cloth.

Eight 2 m x 2 m 170 plate pressure filters will be required for the Cobbora project (for the first four years). Thickener underflow will be pumped to a common feed sump where each pressure filter is fed by a dedicated pump. Each filter feed line contains a flow meter to ensure every filter is fed to capacity. Four pumps (two per filter) will be required to provide the squeeze water for the membranes and another four pumps (two per filter) will provide spray water for the cloth.

The filtrate from the pressure filters will collect in two separate sumps (four filters per sump) and the filtrate will be pumped back to the clarified water tank. There is also an option to recycle the filtrate back to the feed of the pressure filters to remove the build-up in the feed to the filter, but this only occurs occasionally.

Due to the length of the pressure filter (some 30 m long), each filter will require a dedicated collection conveyor underneath. Each collection conveyor will feed a common tailings reject conveyor, which in turn discharges onto the plant reject conveyor.

3.4.2 Pressure filter block flow sheet



3.5 Solid bowl centrifuges

3.5.1 Description

Solid bowl centrifuges are an established technology from the 1980s.. Their small capacity led to them being gradually phased out as plant capacities increased; however, recent advances in their capacity have seen a resurgence of interest. Initially solid bowl centrifuges could only handle small tonnages (20 t/h), whereas the solid bowl centrifuges discussed in this report can process up to 100 t/h. They are relatively new and none have been installed in Australia; however, a trial at a Hunter Valley site will provide better operating data and confidence for selection. The solid bowl centrifuge uses centrifugal forces to dewater the tailings. Flocculant must also be used to produce a clean, solids-free effluent.

Figure 3.8 Solid bowl centrifuge

The solid bowl centrifuge consists of a large ceramic lined bowl that rotates between 700 and 1300 rpm to separate the tailings and water. The tailings will discharge from the end of the solid bowl as a cake and the effluent will discharge beneath the solid bowl at the feed end.

The solid bowl centrifuge will dewater tailings to a final cake moisture of (roughly) 65–75% w/w. The major operating cost for the centrifuge will be the power requirement; each solid bowl contains an 1100 kW motor and a 300 kW transport scroll drive.

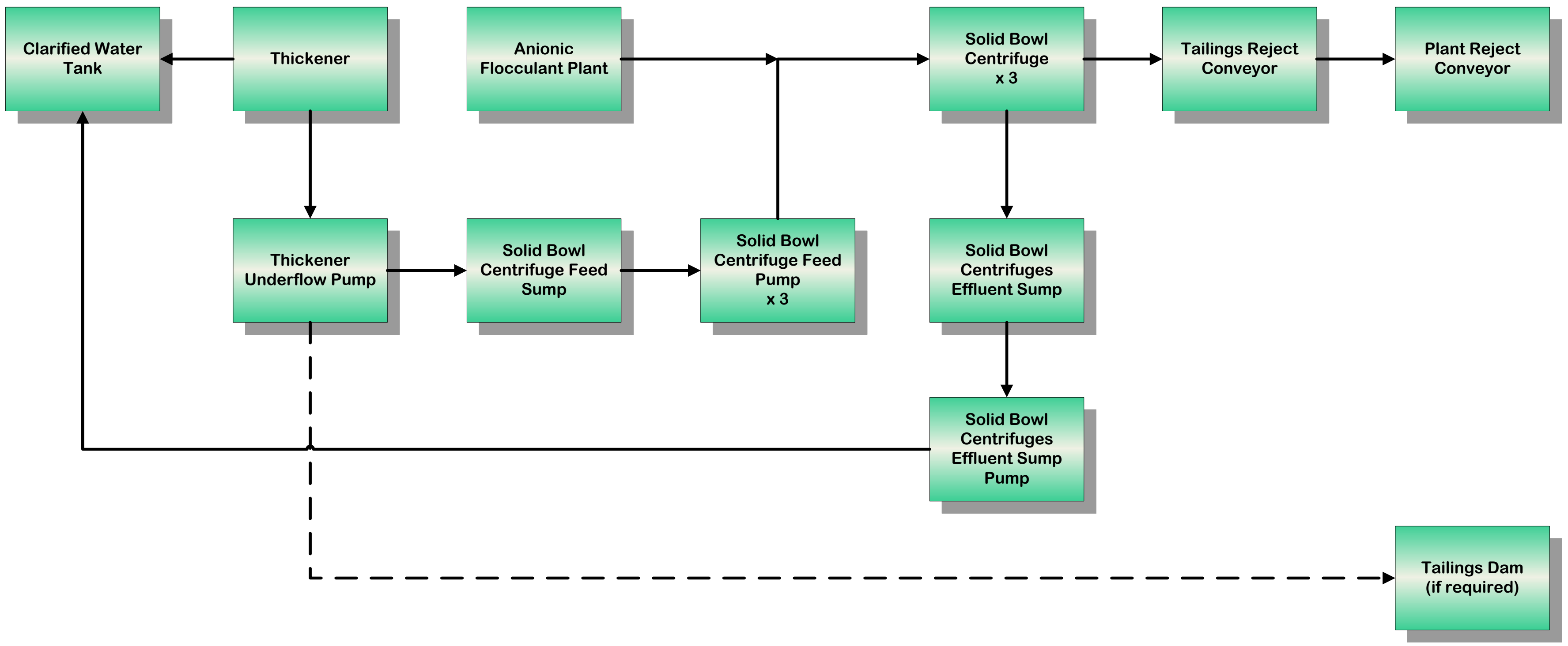
Anionic flocculant is added to the centrifuge feed to give an acceptable effluent water quality. Flocculant dosage will be about 200 g/t (centrifuge feed).

Three solid bowl centrifuges 1400 mm in diameter will be required for the Cobbora plant (for the first four years). Thickener underflow will be pumped to a common solid bowl centrifuge feed sump. Each centrifuge will have a dedicated feed pump to establish a consistent feed to all the machines. The effluent from each centrifuge will be collected in a common sump and pumped to the clarified water tank. The tailings will discharge on a dedicated tailings reject conveyor, which in turn discharges onto the reject conveyor.

A larger or separate anionic flocculant plant will be required than now proposed to supply the extra chemical load for the solid bowl centrifuges.

A tailings dam has been provided to allow the bypass of thickener underflow and maintain plant operation during periods of major maintenance.

3.5.2 Block flow sheet



3.6 Water recycling

The base case and dewatering options considered in this report all recover water from the tailings but to different extents. The water recovered is recycled to the CPP washing process.

The predicted quantity of recycled water for each of the dewatering options over the life of mine is shown in Table 3.6.1 below.

Table 3.6.1 Water recycling over the life of mine

Option	Description	Water Recycled (Gigalitres)
Base case	Thickener + emplacements	14.1
1	Secondary flocculation + emplacements	22.7
2	Thickener + paste thickener	44.7
3	Thickener + belt presses	53.8
4	Thickener + pressure filters	60.8
5	Thickener + solid bowl centrifuges	60.8

For the base case and option 1 the primary thickened tailings are delivered to an emplacement area. In the first period of operation out of pit emplacements would be used and about 30% and 45% respectively of the water delivered to the emplacement is recoverable. Of the balance some is lost in evaporation or seepage but the majority remains entrapped within the emplacements. When the out of pit emplacements have been filled, the tailings would be pumped to in-pit emplacement areas where the water recycled is expected to drop to 15% and 25% respectively of the water delivered in-pit.

Dewatering options 2 through 5 inclusive return higher levels of recycled water since these processes are sited at the CPP plant, and return recycled water directly to the process.

The increasing amount of water recycled in options 2 through 5 is directly related to the dryness of the solid cake in each process. Pressure filters and solid bowl centrifuges produce the driest cakes and therefore have the highest quantities of recycled water.

4. Capital costs

4.1 Cost Comparison

The capital cost estimates in this section provide a comparative order of magnitude capital cost for different options associated with tailings dewatering for the Cobbora project. The following sections consider individual components of the base case and alternatives with a final summary for all options shown in Section 4.1.5.

These capital cost estimates represent the expenditure required at day one of CPP production and are based on systems sized to cater for the initial tailings production rate anticipated in the first four years of mine operation.

4.1.1 Base case dewatering – high rate thickening and disposal to tailings dams

The element breakdown for the base case dewatering system capital cost of $35,063,129 is shown in Table 4.1.

Table 4.1 Base case capital cost

Base case item	Capital cost ($)
Thickener	3,859,761
Tailings disposal pumps	198,646
Associated suction pipelines instruments and controls	417,560
Flocculant plant, piping and controls	474,829
Civil works	3,201,359
Tailings dams	19,808,075
Tailings pipelines	1,233,280
Return water systems and seepage control	2,818608
Indirects	3,051,010
Total	**35,063,129**

4.1.2 Alternative dewatering options capital cost

Table 4.2 is a summary of the capital costs for the alternative dewatering technologies.

Table 4.2 Capital cost comparison of alternative dewatering options

	Secondary flocculation ($)	Paste thickening ($)	Belt press filtration ($)	Pressure filtration ($)	Solid bowl centrifuges ($)
Total capital cost	4,000,000	25,940,312	26,952,593	68,212,717	32,687,016

The secondary flocculation option was not estimated in detail; however, a provisional amount of $4 M would cover the costs of the flocculant plant, civils, water tanks and associated electrics and pipework.

Since all dewatering options are fed from a common tailings underflow stream, an additional capital sum for the thickener, and thickener underflow pumps must be allowed for each alternative dewatering option as shown in Table 4.3.

Table 4.3 Additional treatment costs

Additional pre-treatment costs	Capital cost ($)
Thickener	3,859,761
Thickener underflow pumps	148,646
Associated suction pipelines instruments and controls	297,560
Flocculant plant, piping and controls	474,829
Civil works	3,201,359
Indirects	1,995,539
Total	**9,977,694**

4.1.3 Risk mitigation costs

Discharge of tailings by pumping to a tailings dam is a well-proven means of tailings disposal. To properly assess the alternative dewatering technologies on the same risk basis, it is necessary to consider whether the alternative options can be applied without a backup tailings disposal option.

The SWOT analysis in Appendix 2 nominates the likely requirement for additional backup systems. All the alternative dewatering systems require a backup — a single tailings emplacement area has been chosen as fulfilling this requirement.

The single tailings dam risk mitigation cost is shown below in Table 4.4.

Table 4.4 Risk mitigation costs

Risk mitigation cost	Capital cost ($)
Tailings disposal pumps	198,646
Associated suction pipelines instruments and controls	417,560
Tailings dams	10,551,544
Tailings pipelines	1,016,547
Return water systems and seepage control	1,976,501
Indirects	902,313
Total	**15,063,111**

4.1.4 Additional capital – other affected systems

The capital costs in section 4.1.2 cover the costs for assets within the battery limits of the dewatering unit operation. Other services systems or attached plant are also affected as noted below.

- To upgrade the reject conveyor for an incremental additional capacity of 400 tph will require upgrading the reject conveyor belt from 1050 mm wide to 1200 mm wide at an additional capital cost of $1,004,750. This is shown as additional cost in Table 4.5 where it is applicable. The 400 tph comprises 200 tph dry solids tailings (refer Section 2.3 and 200 tph extra water associated with the dewatered solids (nominally 50% w/w). The actual additional tonnage will be different for each dewatering option but as it would not affect the selected belt width the additional capital cost would be the same for each option.

- Additional reject truck fleet — dewatered material will be transported by truck to the final disposal point. The incremental extra 400 tph cake load means an extra two reject trucks must be bought and additional running costs This cost has been captured as an operating cost of $1.50/tonne (including amortised capital , diesel, maintenance and labour costs) for each of the affected alternative systems in Table 4.5.

- Additional power infrastructure beyond the allowances made in the existing plant — particularly the capacity of the HV electrical system. The solid bowl centrifuge system will likely increase the HV ceiling beyond the 30 MVA site limit. This cost has not been included in the analysis.

4.1.5 Capital cost comparison – all factors

A comparison of the base case and alternative options can be made by incorporating the pre-thickening, alternative plant, capital and risk mitigation costs together so that all options can be considered on the same basis. This data is presented in Table 4.5.

Table 4.5 Overall cost comparison ($)

Component	Base case	Secondary flocculant	Paste thickener	Belt press filters	Pressure filters	Solid bowl centrifuge s
Base cost	35,063,129	35,063,129				
Pre-thickening			9,977,694	9,977,694	9,977,694	9,977,694
Option cost		4,000,000	25,940,312	26,952,953	68,212,717	32,687,016
Risk mitigation			15,063,111	15,063,111	15,063,111	15,063,111
Additional			1,004,750	1,004,750	1,004,750	1,004,750
TOTAL	35,063,129	39,063,129	62,537,411	63,549,692	104,809,816	69,284,115

4.2 Assumptions

Battery limits

- The input battery limit is the feed flange of the high rate thickener (common to all systems).
- The output battery limit is the final discharge point for tailings emplacement (either the tailings or overburden) and the return water discharge point to the clarified water tank.

Estimate

- Equipment pricing has been taken from budget prices, recent projects and QCC database.
- Capital costs in this report are order of magnitude costs constructed using a base level of budget information from suppliers and then applying industry established factors to generate the remaining direct costs of materials and installed labour,
- Indirect costs for engineering, design, project management and commissioning are included as a percentage of the direct costs.
- Labour rates used are current for Upper Hunter Valley coal mine construction as at June 2012.

4.3 Exclusions

- Owner costs
- Spares
- Project escalation including any costs associated with Government Budget changes
- GST
- The effects of the carbon tax
- Costs associated with rehabilitation and ongoing maintenance of tailings dam(s)
- Statutory impost for dam rehabilitation bond

5. Operating costs

Typical operating costs for each of the technologies are compared using data drawn from the comparison table in Section 3.

These operating cost estimates are based on systems sized to cater for the initial tailings production rate anticipated in the first four years of mine operation.

- Labour costs were applied at an average of $166,000/operator.
- Flocculant costs were applied at $4.50/kg for both anionic and cationic chemicals.
- Power costs used were $134 kVa plus usage charge of 3.7 cents/kWh.
- Maintenance costs are an estimate.
- Reject trucking costs provided by CHC include for amortisation of truck capital at $1.50/tonne.

Table 5.1 Comparative operating costs

Dewatering Technologies
Annual Operating Cost Comparison

Item	Base Case - Thickener & Dam	Secondary Flocculation	Paste Thickening	Belt Press Filters	Pressure Filters	Solid Bowl Centrifuges
Labour	$0	$0	$0	$664,000	$664,000	$0
Prethickening Floc	0	$623,160	$623,160	$623,160	$623,160	$623,160
Anionic Floc	$623,160	$2,492,640	$1,218,619	$2,492,640	$0	$1,246,320
Cationic Floc	$0	$0	$0	$1,246,320	$0	$0
Reject Conveying & Trucking	$0	$0	$4,164,802	$3,780,742	$3,199,462	$3,199,462
Power	$183,788	$203,308	$177,533	$142,026	$266,300	$914,294
Maintenance	$0	$80,000	$200,000	$240,000	$892,000	$400,000
Total Annual Cost	$806,948	$3,399,108	$6,384,114	$9,188,888	$5,644,922	$6,383,236

Power Costs include for pumping tails to dam and return water to plant in base case
Labour Costs are incremental costs and applied only if required to operate the additional plant in each system
Prethickening Floc costs apply to the common prethickening stage of each alternative system
Reject Trucking and Conveying costs based on wet cake tonnages produced .

Major Maintenance Items

Secondary Floc	Decant and return water pumps impeller 5% mechanical equipment
Paste Thickener	Hydraulics, Piston Pump heads 3 monthly, hardfacing barrels annual
Belt Press Filter	Filter belts 6monthly, 10% bearings annual, Rollers 10%pa
Pressure Filters	170 cloths x 6machines annual + plate breakage 5% , hydraulics
Solid Bowl Centrifuges	Scroll and bowl rebuild every 2 year

Maintenance cost does not include maintenance labour costs
Sustaining capital not included

6. Life of mine costs

The life of mine costs of all the options have been estimated and are represented in figure 6.1 as net present value.

Life of mine costs includes:

- Initial capital
- additional capital in year four to account for increased mine production
- operation and maintenance
- tailings emplacement closure and rehabilitation.

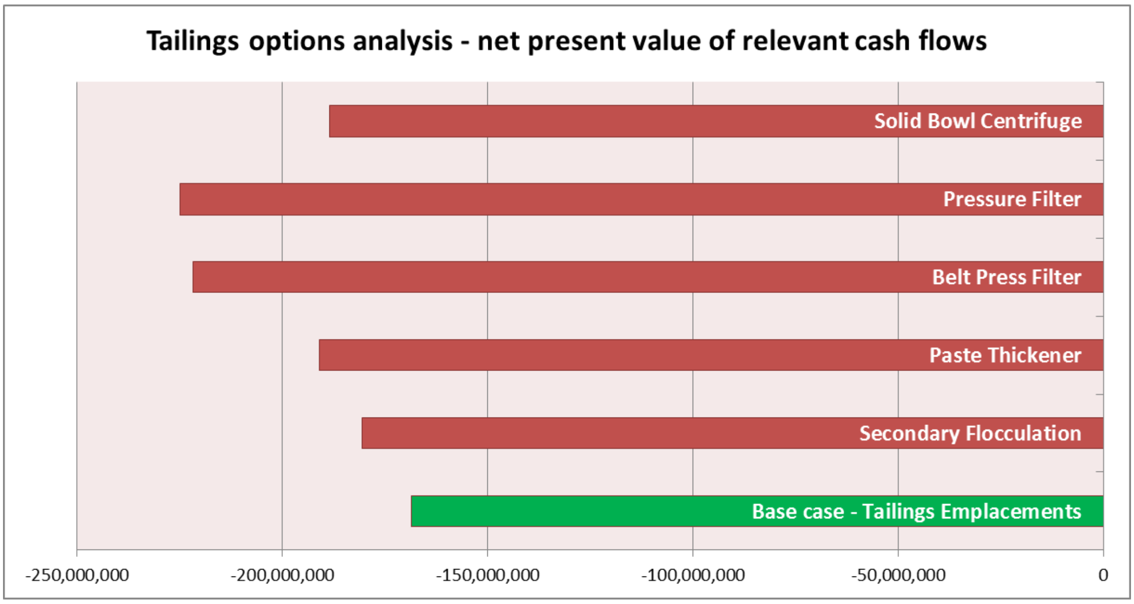


Figure 6.1 Tailings options analysis – net present value of relevant cash flows

As shown the lowest life of mine net present value costs belongs to the base case, tailings storage emplacements. All options have a negative value as no options generate any direct income.

Life of mine cost analysis issued to QCC Resources for this report by Cobbora Holding Company.

7. Discussion

The choice of dewatering system to use for the Cobbora project is subject to a host of technical, economic and environmental criteria. This report focuses on the economic and technical aspects of alternative dewatering systems.

The base case proposal using a high rate thickener and pumping tailings slurry to multiple tailings storage emplacements is a low technical risk solution with low operating cost and moderate capital cost. The life of mine cost for this option is also the lowest even after taking into account the responsible rehabilitation of emplacements. Over a five to ten year horizon, and with appropriate management of the storage emplacement, the ultimate density achieved at the end of tailings placement out of pit would be comparable to alternative systems.

Due to the geographical placement of the two out-of-pit dams at start-up, a secondary flocculant plant at each dam location would be required to service alternating or co-current discharge of tailings. The end result of secondary flocculation would be more overall water recovered for recycling as a result of less evaporation and the likely faster rehabilitation. The price paid for these benefits is the additional operating cost with high flocculant consumption. Bearing in mind the likely accelerated rehabilitation benefit, the application of secondary flocculation could result in the return of the final emplacements to final landform quicker at the end of the mine life.

Paste thickening is an alternative technology that is emerging as a viable process under particular circumstances with coal operators in Australia. There is some technical risk associated with the process that is mitigated in this case by including a single tailings dam as a backup in the event of process failure or a reduction in process throughput. The low power consumption of this option is offset by the higher diesel usage in haulage back to the pit and flocculant consumption.

Belt press filters produce a drier cake than a paste thickener but require slightly more capital. The biggest detriment of belt press filters is the operating cost disadvantage of high flocculant consumption and requirement for dedicated operating labour. Attempts to automate belt press filters to date have not been successful in the coal industry.

Pressure filters have the potential to achieve the driest tailings cake. Unfortunately this technology also carries with it the highest capital cost and the highest technical risk.

The recent (overseas) installation of larger capacity screen bowl centrifuges suggests that this technology has merit; however, there are no operating installations in Australia. Screen bowl centrifuges may be better considered later in the mine's life, if required and adequate power is available on site.

All mechanical dewatering technologies recycle significantly more water compared to the base case, tailings emplacements. Unfortunately the capital and operating cost analysis shows the amount of water recycled has a direct correlation to the increase in:

- embodied energy in installed equipment and structures
- use of flocculants produced by high energy usage processes and/or
- use of electricity.

Without the constraint of space for tailings storage and with the adoption of a responsible tailings emplacement plan that ensures timely rehabilitation it is difficult to justify mechanical dewatering based on environmental grounds.

8. Conclusions and recommendation

It is recommended the Cobbora project adopt the base case thickening design with high rate thickening and discharge to tailings emplacements as the economic alternative.

The initial capital cost of the system is the lowest from the options investigated.

The operating cost is the lowest of the systems investigated.

The life of mine cost of the system is the lowest even when tailings emplacement rehabilitation is accounted for.

The base case thickening technology is also the simplest to operate, has less technical risk and is less sensitive to rising cost inputs for electricity, flocculants and labour into the future.

The environmental benefit of additional water recovery from mechanical dewatering is largely offset by other holistic factors.

Appendix 1 – Equipment lists

Cobbora Project

Paste Thickener Equipment List

Document No: November 2012 Rev A

Component Equip #	Tag No	Description	Max Capacity	Model/Size	Supplier	Power (kW)	Comments
		Coal Processing Plant 200 t/h	Flow Rates are Aprox	200 t/h			
SMP-001		Paste Thickener Feed Sump	3.5m dia x 5.5 high elevated	3.5m dia x 5.5 high elevated	Fabricated		
ZME-001		Settling Rate Monitor No.1			SNF		
PMP-001		Paste Thickener Feed Pump	450-L	450-L	Warman	220	
PMP-002		Paste Thickener Underflow Pump No1	Piston Pump 200 dia x 2800 x	Piston Pump 200 dia x 2800 x	Flowcrete	185	
PMP-003		Paste Thickener Underflow Pump No2	Piston Pump 200 dia x 2800 x	Piston Pump 200 dia x 2800 x	Flowcrete	185	
PMP-004		Paste Thickener Area Sump Pump	100 VE-GPS (1.8m Shaft)	100 VE-GPS (1.8m Shaft)	Warman	55	
PMP-005		Flocculant Transfer Pump	Roto	Roto	Roto	18.5	
PMP-006		Flocculant Dosing Pump No 1	Roto	Roto	Roto	3	
PMP-007		Flocculant Dosing Pump No 2	Roto	Roto	Roto	3	
THR-001		Paste Thickener	30 m dia x 8m sidewall	30 m dia x 8m sidewall	Outotec	132	
HPR-002		Floc Blower Hopper	100 litre	100 litre	SNF		
HPR-001		Bulk Storage Silo	20m3 Pneumatic Fill	20m3 Pneumatic Fill	SNF		

VBR-001		Floc Dust Collector	Shaker Dust Collector	Shaker Dust Collector	SNF	0.55	
VBR-002		Bulk Silo Vibrator	Out of Balance Vibrator	Out of Balance Vibrator	SNF	0.3	
AGI-001		Floc Mix Tank Agitator	Fixed Speed , Twin propeller	Fixed Speed , Twin propeller	Lightnin	2.2	
TNK-001	3101	Flocculant Mixing Tank	Mild Steel, Epoxy Coated	Mild Steel, Epoxy Coated	SNF		
TNK-002	3201	Flocculant Storage Tank	Mild Steel, Epoxy Coated	Mild Steel, Epoxy Coated	SNF		
MIX-001	3202	Flocculant In Line Mixer	Stainless Static Mixer	Stainless Static Mixer	SNF		
BWR-001	3301	Floc Blower			SNF	5.5	
					Total kW's	**810.0**	

Cobbora Project

Belt Press Filter Building Equipment List

Document No: November 2012 Rev A

Component							
Equip #	**Tag No**	**Description**	**Max Capacity**	**Model/Size**	**Supplier**	**Power (kW)**	**Comments**
		Coal Processing Plant 750 t/h	**Flow Rates are Aprox**	**750 t/h**			
AGI-0701		Tailings Anionic Mixer			SNF	3.0	
AGI-0702		Tailings Cationic Mixer			SNF	3.0	
CVR-0001		Tailings Cake Conveyor	243 t/h	762 mm Wide x 55 m Long (20m Elevated)			
CRA-0001		Overhead Crane (Tailings Building)	3 SWL	Single Rail Trolley	Eilbeck or Equivalent	5	
FBP-0701		Tailings Belt Press Filter #1	25 t/h		Phoenix	7	
FBP-0701-3101	3101	Tailings Belt Press Filter Discharge Chute # 1 & 2			Fabrication		
FBP-0701-3301	3301	Tailings Belt Press Filter #1 Underpan			Fabrication		
FBP-0702		Tailings Belt Press Filter #2	25 t/h		Phoenix	7	
FBP-0702-3301	3301	Tailings Belt Press Filter #2 Underpan			Fabrication		
FBP-0703		Tailings Belt Press Filter #3	25 t/h		Phoenix	7.0	
FBP-0703-3101	3101	Tailings Belt Press Filter Discharge Chute #3 & 4			Fabrication		
FBP-0703-3301	3301	Tailings Belt Press Filter #3 Underpan			Fabrication		

FBP-0704		Tailings Belt Press Filter #4	25 t/h		Phoenix	7.0	
FBP-0704-3301	3301	Tailings Belt Press Filter #4 Underpan			Fabrication		
FBP-0705		Tailings Belt Press Filter #5	25 t/h		Phoenix	7	
FBP-0705-3101	3101	Tailings Belt Press Filter Discharge Chute # 5 & 6			Fabrication		
FBP-0705-3301	3301	Tailings Belt Press Filter #5 Underpan			Fabrication		
FBP-0706		Tailings Belt Press Filter #6	25 t/h		Phoenix	7	
FBP-0706-3301	3301	Tailings Belt Press Filter #6 Underpan			Fabrication		
FBP-0707		Tailings Belt Press Filter #7	25 t/h		Phoenix	7.0	
FBP-0707-3101	3101	Tailings Belt Press Filter Discharge Chute # 7 & 8			Fabrication		
FBP-0707-3301	3301	Tailings Belt Press Filter #7 Underpan			Fabrication		
FBP-0708		Tailings Belt Press Filter #8	25 t/h		Phoenix	7.0	
FBP-0708-3301	3301	Tailings Belt Press Filter #8 Underpan			Fabrication		
FBP-0709		Tailings Belt Press Filter #9	25 t/h		Phoenix	7	
FBP-0709-3101	3101	Tailings Belt Press Filter Discharge Chute # 9 & 10			Fabrication		
FBP-0709-3301	3301	Tailings Belt Press Filter #9 Underpan			Fabrication		
FBP-0710		Tailings Belt Press Filter #10	25 t/h		Phoenix	7	
FBP-0710-3301	3301	Tailings Belt Press Filter #10 Underpan			Fabrication		
FDS-0703		Belt Press Filters Anionic Flocculant System			SNF		

FDS-0704		Belt Press Filters Cationic Flocculant System			SNF		
FLT-0001		Filter Wash water Filter #1	70 m³/h	Self Cleaning DN100	Amiad	0.0	
FLT-0002		Filter Wash water Filter #2	70 m³/h	Self Cleaning DN100	Amiad	0.0	
FLT-0003		Filter Wash water Filter #3	70 m³/h	Self Cleaning DN100	Amiad	0.0	
FLT-0004		Filter Wash water Filter #4	70 m³/h	Self Cleaning DN100	Amiad	0.0	
FLT-0005		Filter Wash water Filter #5	70 m³/h	Self Cleaning DN100	Amiad	0.0	
MIX-0701		Belt Filters Feed Sump Mixer		A Series Blades	Lightn	30.0	
PMP-0701		Tailings Belt Press Filter Feed Pump #1	100 m³/h	4/3 C-AH	Warman	18.5	
PMP-0702		Tailings Belt Press Filter Feed Pump #2	100 m³/h	4/3 C-AH	Warman	18.5	
PMP-0703		Tailings Belt Press Filter Feed Pump #3	100 m³/h	4/3 C-AH	Warman	18.5	
PMP-0704		Tailings Belt Press Filter Feed Pump #4	100 m³/h	4/3 C-AH	Warman	18.5	
PMP-0705		Tailings Belt Press Filter Feed Pump #5	100 m³/h	4/3 C-AH	Warman	18.5	
PMP-0706		Tailings Belt Press Filter Feed Pump #6	100 m³/h	4/3 C-AH	Warman	18.5	
PMP-0707		Tailings Belt Press Filter Feed Pump #7	100 m³/h	4/3 C-AH	Warman	18.5	
PMP-0708		Tailings Belt Press Filter Feed Pump #8	100 m³/h	4/3 C-AH	Warman	18.5	
PMP-0709		Tailings Belt Press Filter Feed Pump #9	100 m³/h	4/3 C-AH	Warman	18.5	
PMP-0710		Tailings Belt Press Filter Feed Pump #10	100 m³/h	4/3 C-AH	Warman	18.5	
PMP-0711		Tailings Anionic Transfer Pump			SNF	1.1	

PMP-0712		Tailings Anionic Dosing Pump #1			SNF	1.1	
PMP-0713		Tailings Anionic Dosing Pump #2			SNF	1.1	
PMP-0714		Tailings Cationic Dosing Pump #1			SNF	1.1	
PMP-0715		Tailings Cationic Dosing Pump #2			SNF	1.1	
PMP-0716		Tailings Belt Press Filters Effluent Pump	464 m³/h	8/6 E-AH	Warman	45.0	
PMP-0717		Belt Filter Building Floor Pump	80 m³/h	100 SP	Warman	18.5	
PMP-0718		Tailings Belt Press Filters Spray Pump #1	70 m³/h	CRN(E) 64-4	Grundfos	22.0	
PMP-0719		Tailings Belt Press Filters Spray Pump #2	70 m³/h	CRN(E) 64-4	Grundfos	22.0	
PMP-0720		Tailings Belt Press Filters Spray Pump #3	70 m³/h	CRN(E) 64-4	Grundfos	22.0	
PMP-0721		Tailings Belt Press Filters Spray Pump #4	70 m³/h	CRN(E) 64-4	Grundfos	22.0	
PMP-0722		Tailings Belt Press Filters Spray Pump #5	70 m³/h	CRN(E) 64-4	Grundfos	22.0	
PMP-0723		Flocculant Water Makeup Pump	50 m³/h	CRN(E) 1-1	Grundfos	4.0	
SMP-0701		Belt Filters Feed Sump	676 m³/h	Ø4.8m x 5.4 m High (90m^3)	Fabrication		
SMP-0702		Tailings Belt Press Filters Effluent Sump	464 m³/h		Fabrication		
SMP-0703		Belt Filter Building Floor Sump	80 m³/h		Concrete		
TNK-0701		Tailings Anionic Concentrate Tank			SNF		
TNK-0702		Tailings Anionic Dilute Tank			SNF		
TNK-0703		Tailings Cationic Concentrate Tank			SNF		

TNK-0704		Tailings Spray Water Tank		Ø4.0m x 4.0 m High ($50m^3$)	Fabrication		
					Total kW's	**479.0**	

Cobbora Project Filter Press Building Equipment List Document No: November 2012 Rev A							
Component							
Equip #	Tag No	Description	Max Capacity	Model/Size	Supplier	Power (kW)	Comments
		Coal Processing Plant 750 t/h	Flow Rates are Aprox	750 t/h			
ARC-0701		Filter Press Air Receiver		25 m³ Capacity			
CVR-0001		Tailings Cake Conveyor	243 t/h	762 mm Wide x 55 m Long (20m Elevated)			
CVR-0701		Filter Press #1 Conveyor	100 t/h	762 mm Wide x 30 m Long (20m Elevated)		5.5	
CVR-0702		Filter Press #2 Conveyor	100 t/h	762 mm Wide x 30 m Long (20m Elevated)		5.5	
CVR-0703		Filter Press #3 Conveyor	100 t/h	762 mm Wide x 30 m Long (20m Elevated)		5.5	
CVR-0704		Filter Press #4 Conveyor	100 t/h	762 mm Wide x 30 m Long (20m Elevated)		5.5	
CVR-0705		Filter Press #5 Conveyor	100 t/h	762 mm Wide x 30 m Long (20m Elevated)		5.5	
CVR-0706		Filter Press #6 Conveyor	100 t/h	762 mm Wide x 30 m Long (20m Elevated)		5.5	
CVR-0707		Filter Press #7 Conveyor	100 t/h	762 mm Wide x 30 m Long (20m Elevated)		5.5	
CVR-0708		Filter Press #8 Conveyor	100 t/h	762 mm Wide x 30 m Long (20m Elevated)		5.5	
CMP-0701		Filter Press Air Compressor		GA75		75	
CMP-0702		Filter Press Air Compressor		GA75		75	

CRA-0001		Overhead Crane (Tailings Building)	3 SWL	Single Rail Trolley	Eilbeck or Equivalent	5	
MIX-0701		Filter Press Feed Sump Mixer		A Series Blades	Lightn	30.0	
PFF-0701		Filter Press #1	40 t/h		McLanahan	26	
PFF-0701-3101	3101	Filter Press #1 Feed Chute			Fabrication		
PFF-0701-3201	3201	Filter Press #1 Bombay Door #1			Fabrication		
PFF-0701-3202	3202	Filter Press #1 Bombay Door #2			Fabrication		
PFF-0701-3301	3301	Filter Press #1 Collection Launder #1			Fabrication		
PFF-0701-3302	3302	Filter Press #1 Collection Launder #2			Fabrication		
PFF-0702		Filter Press #2	40 t/h		McLanahan	26	
PFF-0702-3101	3101	Filter Press #2 Feed Chute			Fabrication		
PFF-0702-3201	3201	Filter Press #2 Bombay Door #1			Fabrication		
PFF-0702-3202	3202	Filter Press #2 Bombay Door #2			Fabrication		
PFF-0702-3301	3301	Filter Press #2 Collection Launder #1			Fabrication		
PFF-0702-3302	3302	Filter Press #2 Collection Launder #2			Fabrication		
PFF-0703		Filter Press #3	40 t/h		McLanahan	26	
PFF-0703-3101	3101	Filter Press #3 Feed Chute			Fabrication		
PFF-0703-3201	3201	Filter Press #3 Bombay Door #1			Fabrication		
PFF-0703-3202	3202	Filter Press #3 Bombay Door #2			Fabrication		

PFF-0703-3301	3301	Filter Press #3 Collection Launder #1			Fabrication		
PFF-0703-3302	3302	Filter Press #3 Collection Launder #2			Fabrication		
PFF-0704		Filter Press #4	40 t/h		McLanahan	26	
PFF-0704-3101	3101	Filter Press #4 Feed Chute			Fabrication		
PFF-0704-3201	3201	Filter Press #4 Bombay Door #1			Fabrication		
PFF-0704-3202	3202	Filter Press #4 Bombay Door #2			Fabrication		
PFF-0704-3301	3301	Filter Press #4 Collection Launder #1			Fabrication		
PFF-0704-3302	3302	Filter Press #4 Collection Launder #2			Fabrication		
PFF-0705		Filter Press #5	40 t/h		McLanahan	26	
PFF-0705-3101	3101	Filter Press #5 Feed Chute			Fabrication		
PFF-0705-3201	3201	Filter Press #5 Bombay Door #1			Fabrication		
PFF-0705-3202	3202	Filter Press #5 Bombay Door #2			Fabrication		
PFF-0705-3301	3301	Filter Press #5 Collection Launder #1			Fabrication		
PFF-0705-3302	3302	Filter Press #5 Collection Launder #2			Fabrication		
PFF-0706		Filter Press #6	40 t/h		McLanahan	26	
PFF-0706-3101	3101	Filter Press #6 Feed Chute			Fabrication		
PFF-0706-3201	3201	Filter Press #6 Bombay Door #1			Fabrication		
PFF-0706-3202	3202	Filter Press #6 Bombay Door #2			Fabrication		

PFF-0706-3301	3301	Filter Press #6 Collection Launder #1			Fabrication		
PFF-0706-3302	3302	Filter Press #6 Collection Launder #2			Fabrication		
PFF-0707		Filter Press #7	40 t/h		McLanahan	26	
PFF-0707-3101	3101	Filter Press #7 Feed Chute			Fabrication		
PFF-0707-3201	3201	Filter Press #7 Bombay Door #1			Fabrication		
PFF-0707-3202	3202	Filter Press #7 Bombay Door #2			Fabrication		
PFF-0707-3301	3301	Filter Press #7 Collection Launder #1			Fabrication		
PFF-0707-3302	3302	Filter Press #7 Collection Launder #2			Fabrication		
PFF-0708		Filter Press #8	40 t/h		McLanahan	26	
PFF-0708-3101	3101	Filter Press #8 Feed Chute			Fabrication		
PFF-0708-3201	3201	Filter Press #8 Bombay Door #1			Fabrication		
PFF-0708-3202	3202	Filter Press #8 Bombay Door #2			Fabrication		
PFF-0708-3301	3301	Filter Press #8 Collection Launder #1			Fabrication		
PFF-0708-3302	3302	Filter Press #8 Collection Launder #2			Fabrication		
PMP-0701		Filter Press Feed Pump #1	250 m³/h	8/6 E-AH	Warman	45.0	
PMP-0702		Filter Press Feed Pump #2	250 m³/h	8/6 E-AH	Warman	45.0	
PMP-0703		Filter Press Feed Pump #3	250 m³/h	8/6 E-AH	Warman	45.0	
PMP-0704		Filter Press Feed Pump #4	250 m³/h	8/6 E-AH	Warman	45.0	

PMP-0705		Filter Press Feed Pump #5	250 m³/h	8/6 E-AH	Warman	45.0	
PMP-0706		Filter Press Feed Pump #6	250 m³/h	8/6 E-AH	Warman	45.0	
PMP-0707		Filter Press Feed Pump #7	250 m³/h	8/6 E-AH	Warman	45.0	
PMP-0708		Filter Press Feed Pump #8	250 m³/h	8/6 E-AH	Warman	45.0	
PMP-0709		Filter Press Filtrate Sump Pump #1	250 m³/h	8/6 E-AH	Warman	45.0	
PMP-0710		Filter Press Filtrate Sump Pump #2	250 m³/h	8/6 E-AH	Warman	45.0	
PMP-0711		Filter Press Building Floor Pump #1	80 m³/h	100 SP	Warman	18.5	
PMP-0712		Filter Press Building Floor Pump #2	80 m³/h	100 SP	Warman	18.5	
PMP-0713		Filter Wash Water Pump #1	70 m³/h	4/3 C-AH	Warman	22.0	
PMP-0714		Filter Wash Water Pump #2	70 m³/h	4/3 C-AH	Warman	22.0	
PMP-0715		Filter Wash Water Pump #3	70 m³/h	4/3 C-AH	Warman	22.0	
PMP-0716		Filter Wash Water Pump #4	70 m³/h	4/3 C-AH	Warman	22.0	
PMP-0717		Squeeze Water Pump #1	70 m³/h	4/3 C-AH	Warman	22.0	
PMP-0718		Squeeze Water Pump #2	70 m³/h	4/3 C-AH	Warman	22.0	
PMP-0719		Squeeze Water Pump #3	70 m³/h	4/3 C-AH	Warman	22.0	
PMP-0720		Squeeze Water Pump #4	70 m³/h	4/3 C-AH	Warman	22.0	
SMP-0701		Filter Press Feed Sump	676 m³/h	Ø4.8m x 5.4 m High (90m^3)	Fabrication		
SMP-0702		Press Filter Filtrate Sump #1	230 m³/h		Fabrication		

SMP-0703		Press Filter Filtrate Sump #2	230 m³/h		Fabrication		
SMP-0704		Squeeze Water Sump	230 m³/h		Fabrication		
SMP-0705		Wash Water Sump	230 m³/h		Fabrication		
SMP-0706		Belt Filter Building Floor Sump	80 m³/h		Concrete		
SMP-0707		Belt Filter Building Floor Sump	80 m³/h		Concrete		
					Total kW's	**1100.0**	

Cobbora Project

Solid Bowl Centrifuge Building Equipment List

Document No: November 2012 Rev A

TAG no.	Component		Description	Max Capacity	Model/Size	Supplier	Power (kW)	Comments
	Equip #	Tag No						
325			Coal Processing Plant 200t/h	Flow Rates are Aprox	200 t/h			
701	AGI-0701		Tailings Anionic Mixer			SNF	3.0	
001	CVR-0001		Tailings Cake Conveyor	243 t/h	762 mm Wide x 55 m Long (20m Elevated)			
001	CRA-0001		Overhead Crane (Tailings Building)	20 SWL	Single Rail Trolley	Eilbeck or Equivalent	42.7	
701	CTF-0701		Solid Bowl Centrifuge #1	100 t/h		Phoenix	1420	
701	CTF-0701-3101	3101	Solid Bowl Centrifuge #1 Discharge Chute			Fabrication		
701	CTF-0701-3301	3301	Solid Bowl Centrifuge #1 Underpan			Fabrication		
702	CTF-0702		Solid Bowl Centrifuge #2	100 t/h		Phoenix	1420	
702	CTF-0702-3101	3101	Solid Bowl Centrifuge #2 Discharge Chute			Fabrication		
702	CTF-0702-3301	3301	Solid Bowl Centrifuge #2 Underpan			Fabrication		
703	CTF-0703		Solid Bowl Centrifuge #3	100 t/h		Phoenix	1420.0	
703	CTF-0703-3101	3101	Solid Bowl Centrifuge #3 Discharge Chute			Fabrication		
703	CTF-0703-3301	3301	Solid Bowl Centrifuge #3 Underpan			Fabrication		

701	FDS-0701		Solid Bowl Centrifuges Anionic Flocculant System			SNF		
701	MIX-0701		Solid Bowl Centrifuges Feed Sump Mixer		A Series Blades	Lightn	30.0	
701	PMP-0701		Solid Bowl Centrifuge Feed Pump #1	300 m³/h	8/6 E-AH	Warman	30.0	
702	PMP-0702		Solid Bowl Centrifuge Feed Pump #2	300 m³/h	8/6 E-AH	Warman	30.0	
703	PMP-0703		Solid Bowl Centrifuge Feed Pump #3	300 m³/h	8/6 E-AH	Warman	30.0	
704	PMP-0704		Tailings Anionic Transfer Pump			SNF	1.1	
705	PMP-0705		Tailings Anionic Dosing Pump #1			SNF	1.1	
706	PMP-0706		Tailings Anionic Dosing Pump #2			SNF	1.1	
707	PMP-0707		Solid Bowl Centrifuges Effluent Pump	464 m³/h	8/6 E-AH	Warman	45.0	
708	PMP-0708		Solid Bowl Centrifuge Building Floor Pump	80 m³/h	100 SP	Warman	18.5	
709	PMP-0709		Flocculant Water Makeup Pump	50 m³/h	CRN(E) 1-1	Grundfos	4.0	
701	SMP-0701		Solid Bowl Centrifuges Feed Sump	676 m³/h	Ø4.8m x 5.4 m High (90m^3)	Fabrication		
702	SMP-0702		Solid Bowl Centrifuges Effluent Sump	464 m³/h		Fabrication		
703	SMP-0703		Tailings Building Floor Sump	80 m³/h		Concrete		
701	TNK-0701		Tailings Anionic Concentrate Tank			SNF		
702	TNK-0702		Tailings Anionic Dilute Tank			SNF		
						Total kW's	**4496.5**	

Appendix 2 – SWOT analysis

Cobbora Dewatering Option Report SWOT Analysis

Appendix 2
Revision : B
Revision Date : 15.01.2013

STRENGTHS		WEAKNESSES	
High Rate Thickener (Base Case)	**Belt Press Filters**	**High Rate Thickener (Base Case)**	**Belt Press Filters**
Cheapest Capital Cost	Moderately high solids contents of tails cake	Least total water recycle compared with all options	Multiple (10) machines to treat the capacity
High Reliability - most Australian CPPs use this method			Typically can require an additional fulltime and additional part time operator
Easy to operate process			Highest flocculant consumer
			Requires both cationic and anionic dosing to be effective
			Unreliable control (recent Coal Prep Society presentation indicates still
			a need for additional operators)
			Requires a backup tails dam to positively secure reliable operation
Secondary Flocculation	**Pressure Filters**	**Secondary Flocculation**	**Pressure Filters**
Achieves similar initial emplacement density as Paste thickener	Can deliver a high product solids content	Very high operating cost- high flocculant consumption	Susceptible to Cloth Blinding which increases cycle time and reduces capacity
Proven system at a number of Australian CPPs	Does not require flocculant		Typically requires additional operator intervention to maintain full capacity
Allows top of bed to dry by evaporation leading to earlier rehabilitationg timing			Highest Capital Cost
			Largest building volume
			Requires a backup tails dam to positively secure reliable operation
Paste Thickener	**Solid Bowl Centrifuges**	**Paste Thickener**	**Solid Bowl Centrifuges**
Single Unit to treat the entire tails stream	Can deliver a high product solids content	Can deliver a conveyable product but is susceptible to expandable clay variances	Very High Power consumption (2 MW per machine installed power)
Moderate power use	High Unit capacity	Lowest Tailings Cake moisture	High Maintenance Cost
Moderate flocculant use	Low number of units assists management of operations	Requires a backup tails dam to positively secure reliable operation	Requires a backup tails dam to positively secure reliable operation
Does not require any additional operators to maintain			
Long cycles between maintenance (3 months)			
Minimum Spare parts requirements			
Cheapest Overall Cost compared with other mechanical options			

OPPORTUNITIES		THREATS	
High Rate Thickener (Base Case)	**Belt Press Filters**	**High Rate Thickener (Base Case)**	**Belt Press Filters**
	Codisposal with coarse material minimises storage footprint		Expandable clays can severly affect performance
	Remote site location would reduce truck costs		
Secondary Flocculation	**Pressure Filters**	**Secondary Flocculation**	**Pressure Filters**
	Codisposal with coarse material minimises storage footprint		Previous Failures in Hunter Valley Tails Application
	Could locate pressure filter dewatering at the overburden		Batch operation
Paste Thickener	**Solid Bowl Centrifuges**	**Paste Thickener**	**Solid Bowl Centrifuges**
Codisposal with coarse material minimises storage footprint	Codisposal with coarse material minimises storage footprint	needs a standby tailings line to dispose of excess tailings that	Unproven in Australian Coal Industry (One site embarking on trial)
All recycled water can be recovered at the CHPP site	Represents good potential for achieving lowest moisture product	cannot be co-disposed	Very high total power requires a full redesign of Cobbora HV system capacity
Will achieve high solids content quickly with evaporation	Remote site location would reduce truck costs	Co disposal capacity limited to blending ratio of 6 parts dry coarse reject to	
Site paste thickener at point of disposal and avoid trucking costs		1 part dry tailings	