Fingerboards Mineral Sands Project Inquiry and Advisory Committee
Technical note

TN No: TN 022
Date: 17 May 2021
Subject: Response to MFG's request for further information in relation to the water balance modelling

REQUEST FOR FURTHER INFORMATION

During cross examination of Mr Jarrah Muller on hearing day 4 (6 May 2021), MFG asked Mr Muller to:

- provide the spreadsheet which was provided to him by Wave to inform his update of the water balance to include centrifuges;
- explain how the water balance changes if the 73% solids concentration number in the spreadsheet is changed to 63%.

RESPONSE

This technical note is provided in response to the requests made of Mr Muller.

1. Water balance spreadsheet

Mr Stefan Wolmarans of Wave provided spreadsheet 5253-30-CAL-PR-00006.xlsx to Mr Muller on 22 January 2021. A pdf copy of the spreadsheet and the cover email are included in Appendix 1. Further clarification emails between Mr Muller and Mr Wolmarans are included in Appendix 2. The spreadsheet includes three sheets as follows:

- The first sheet (Appendix 1, pdf pages 2 and 3) is the original data that was used in the EES water balance. This data was not changed, apart from shading some cells and putting some comments in bold to highlight them.
- The second sheet (Appendix 1, pdf pages 4 and 5) revises the data used in the EES water balance to account for the use of centrifuges. It was kept in the format of the original EES data so that the areas where changes were made were clear for Mr Muller. The upper portion of the sheet was "greyed out" as it represents the water flows inside the mineral processing plant and was not changed. What changed are the water flows outside the mineral processing plant.
- The third sheet (Appendix 1, pdf page 6) is a summary sheet that references the data from the earlier sheets in a side-by-side manner for easy comparison of the changes.

An extract of the spreadsheet summary table is set out below, with the addition of red reference numbers in the left-hand column, which are referred to below with additional information.

Ref #	Original EESWater Balance		Revised Centrifuge Water Balance		Comments
		ML/year		ML/year	
	Coarse Sand				
1	Water out in sand slurry to cyclone	- 17,850	Water out in sand slurry to cyclone	- 11,787	Silt cut to fines is `100tph more in the centrifuge model and 38% slurry vs 31% slurry density
2	Water in from Cyclone O/F	13,585	Water in from Cyclone O/F	9,483	Less water in due to lower inflow, but higher recover % due to increase to 73% U/F density
3	Water out in Cyclone U/F	- 4,265	Water out in Cyclone U/F	- 2,304	Less due to increased UF density
4	Water in from sand underdrainage recov	2,559	Water in from sand underdrainage recov	1,152	Less due to increased UF density
	Total Recovery	**90.4%**	**Total Recovery**	**90.2%**	
5	Water lost to entrainment and seepage	- 1,706	Water lost to entrainment and seepage	- 1,152	Less due to lower water out in cyclone U/F -final pulp density still the same at 85%
6	As a percentage of Cyclone U/F water	**40.0%**	As a percentage of Cyclone U/F water	**50.0%**	Less because final density is the same and centrifuge starting density is higher
	Fines		**Fines**		
7	Water out	5,601	Water out	7,272	More in centrifuge because of silt cut higher to centrifuge
8	Water in	4,486	Water in	5,812	Relative increase
9	Recovery	**80.1%**	Recovery	**79.9%**	72.7% modelled pulp density vs 73% in EES

2. Water Balance Influencing Factors

The water balance is affected by the amount of water that "crosses the fence" at the process plant to tailings. If more water can be recycled within the process plant water circuits, then the volume of water available for ex-plant tailings losses is reduced. This applies regardless of whether centrifuges are adopted or not.

It is important to note that the introduction of centrifuges affects the following aspects of the EES water balance, each of which is discussed further below:

- Coarse sand mass and density from plant to void
- Coarse sand water recovery to final density
- Fines tailings water recovery

3. Coarse sand mass and density from plant to void

3.1 In-Plant Improvements

The percentage solids in the sand slurry from the process plant to the void was increased from 31% to 38% as this is influenced by the addition of water in the process plant sand tailing pump tank and can be controlled. The sand tailings density is controlled by cycloning the sand tailings from the WCP inside the plant before discharge to the sand tailings tank. This is the same method proposed in the EES and the only change is that the density has been increased. A solids density of 30% - 40% is a range that is readily achievable with the Fingerboards sand tailings. The reason for making the change is to improve in-plant water recovered through readily available means. This contributes to the reduction from 17,850 ML/year (Ref 1).

The grade of the HMC is managed to ensure that the activity concentration remains below 10Bq/g. A portion of the coarse sand tailings >500 micron is scalped with the feed screens and fed back into the HMC after the WCP to ensure that the activity concentration remain at a target of 9.5Bq/g. This further reduces the mass of sand tailings that is recycled with the process plant rather than being pumped to the mine void (Ref 1).

3.2 Ex-Plant reductions

In the process plant, the fines tailings are created by separating the clay and silts smaller than 38 micron from the ore through the use of hydro-cyclones.

In the EES, it is assumed that the coarse sand mass is the total mass of material greater than 38 micron, less the mass of the HMC and fine tailings removed. However, hydro-cyclones do not "cut" precisely at a specific size, but across a narrow range of sizing. This is simply inherent in the design of hydro-cyclones. Therefore, in order to remove most of the material less than 38 micron, the hydro-cyclones also remove a portion of the material greater than 38 micron, approximately up to 45 micron. This is demonstrated graphically below as the area in the red band. Consequently, the coarse sand tailings mass reduces (Ref 1) and fine tailings mass increases (Ref 7).

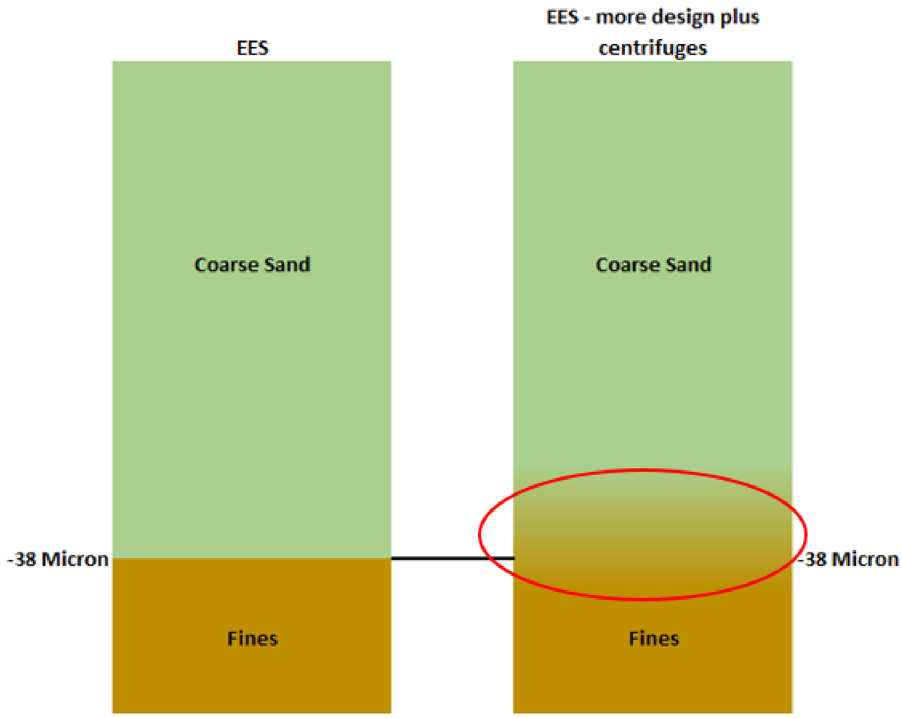

Figure 1 – material removed in hydro-cyclones (around 38 micron)

The practical effect of this is that there is more silt mass going to the centrifuge plant as fines and slightly less silt going to the mine void as coarse sand, than what was assumed in the EES. Because there is less coarse sand going to the mine void, less water is going to the void in the sand slurry - this is the other reason for the reduction from 17,850 to 11,787 tph for the sand tails (Ref 1).

3.3 Coarse sand water recovery to final density

There is a practical limit to the extent of water recovery that can be achieved from the coarse sand tailings. The water balances prepared for both the EES and the centrifuge options kept it a point of approximately 85% solids content slurry density. The final density is not the lowest that the coarse sand will dewater to, it just represents a conservative assumption of the practical limit of water recovery to the process plant that may be achieved. Based on moisture migration testwork, it was observed that the sand tailings will dewater to a point of 80% solids over a period of 30 days. In full-scale sand stacking operations the increased compaction density of the material under self-weight consolidation will increase the sand dewatering compared to the test result. In both the revised centrifuge and EES water balances it has been assumed that the longer-term drainage period (longer than the 30 days test period), together with increased compaction will result in practical water recovery to 85% solids density. In order to maintain a degree of conservatism in the water balance a higher dewatering point was not adopted as 85% was considered appropriate, although it may be possible.

If there is an ultimate limit to the final sand density, then it has the effect that if the coarse sand placement density is higher, then the water recovery percentage to the final density will be lower, and vice versa. The sand placement density was increased from 65% to 73.4% by using two stage cyclone dewatering as this improves the immediate water recovery. Consequently, the water recovery percentage from underdrainage was reduced from 60% in the EES case to 50% in the centrifuge case to reflect the additional water recovered by the two stage cyclones (Ref 6).

4. Fines tailings water recovery

4.1 Centrifuge solids content

The fines tailings dewatering percentage is controlled by the centrifuges. In the EES case, the amount of water recovery from the "mudmasters" was overestimated by assuming that all water up to a density of 73% would be recovered to the process. That percentage will be less in practice as there are significant evaporation losses from the placed fines tailings in the TSF. In the centrifuge case, the evaporation and entrainment losses are negated which improves process water recovery (Ref 8 and 9).

5. Conclusion

The net effect of the above factors is that there is less water deported to the mine void with the coarse sand tails and more water going to the centrifuge plant as fines than was assumed in the EES. For the water retained in the sand tails and lost to seepage, the final density after underdrainage water recovery is identical for both cases at 85%.

6. Effect of changing the 73% solids on fine tailings to 63%

6.1 Water Balance Sensitivity

During the IAC hearing, Kalbar was requested to investigate the impact on water balance if the centrifuges could only achieve a density of 63% rather than the 73% target in the current water balance. The effect of this change would be that the water recovery from the centrifuges would reduce by 0.83GL per year (Ref 8 below)

Ref #	Original EESWater Balance		Revised Centrifuge Water Balance		Comments
	Fines		**Fines**		
7	Water out	5,601	Water out	7,272	More in centrifuge because of silt cut higher to centrifuge
8	Water in	4,486	Water in	4,989	Cake density reduced to 63% solids
9	Recovery	**80.1%**	Recovery	**68.6%**	63% modelled pulp density vs 73% in EES

However, this is not a realistic scenario based on the current centrifuge testwork results. For the reasons described in section 3.2 and 6.2 of this technical note, the centrifuge feed contains a higher relative percentage of clays than the P1 feed material and therefore the percentage solids in the P1 fines cake will always be lower than what will be achieved with a full scale centrifuge processing the WCP fines, which contains higher silts percentage silts relative to clay content.

6.2 Factors affecting centrifuge cake density between P1 and full scale operations

Fines tailings contain a proportion of clay and a proportion of silt particles. Clays are the only particles that actively absorb water. If there is less silt and more clay, then the final cake moisture is higher even though there is no free water. Likewise, if the silt is higher and the clay is less, then the final cake moisture will be less and still have no free water. In other words, the absorbed water content can remain constant, even when the solids content changes.

The percentage silt in the fines tailings is affected by the method used to remove the fine tailings less than 38 micron from the ore. In smaller tonnages used in laboratory settings, a sieve is used as it can cut precisely at a specific particle size. This precision is very important for metallurgical and geological testwork programmes.

In larger operations and demonstration programmes, the fines are not removed by sieve, but through hydro-cyclones. As explained in section 3.2, the cyclone will tend to cut coarser than the sieve when removing the minus 38 micron particles which carries over a portion of the material up to 45 Micron into the fines. Therefore, the centrifuge feed during operations will contain a higher percentage of silts than the sieve material used in the P1 trials. This is planned and does not affect the validity of the trials as it is an expected condition for the laboratory test program. In the larger P2 trials the fines will be removed with an identical cyclone proposed for the P3 operational plant.

This is graphically illustrated in Figure 2 below.

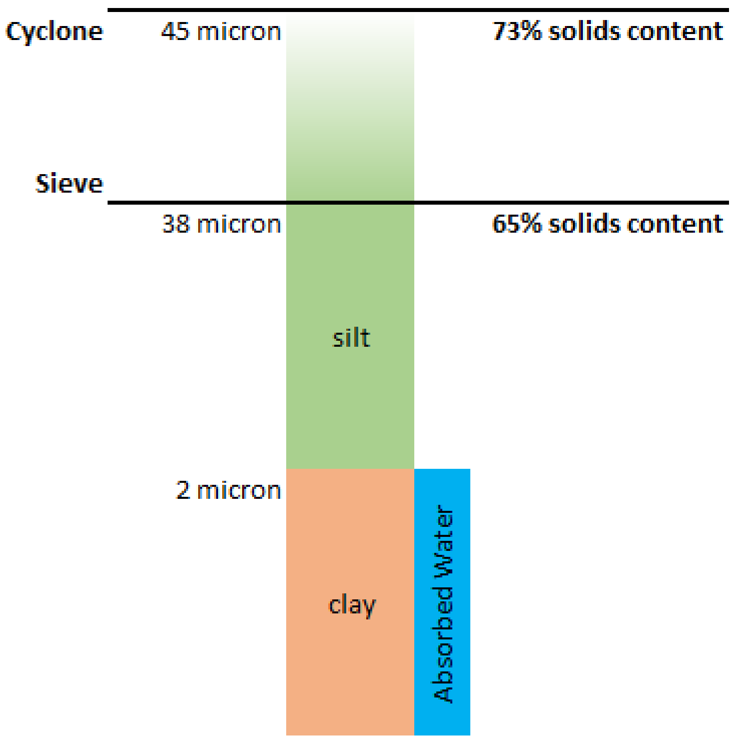

Figure 2 – clay:silt ratio and absorbed water content

APPENDICES 1 AND 2 PROVIDED SEPARATELY