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BROWNS RANGE PROJECT

Tailings Geotechnical and Rheological Laboratory Testing

REPORT

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Executive Summary

This report has been prepared to summarise the results of the geotechnical and rheological tests carried out by Golder Associates Pty Ltd as part of the preliminary options studies for tailings management at the Browns Range Project. The laboratory testing was carried out on tailings samples provided by Northern Minerals Pty Ltd. The scope of the tests was to characterise and estimate the behaviour of the tailings during dewatering, transporting and once deposited to a dedicated TSF.

The tests were undertaken on samples of beneficiation tailings (floatation and magnetic tailings) and hydrometallurgical tailings. The majority of the tests were carried out on sample of floatation tailings combined with hydrometallurgical tailings and commercial gypsum.

The following geotechnical tests were carried out on samples of floatation, magnetic and hydrometallurgical tailings:

- Particle size distribution (PSD)
- Specific gravity (SG) of particles

The following geotechnical tests were carried out on samples of floatation tailings combined with hydrometallurgical tailings and commercial gypsum:

- Atterberg limits test
- Consolidation tests: settling tests, slurry consolidometer, drying tests (air, summer and winter cycles drying tests)
- Permeability tests

The following rheological tests were carried out on samples of floatation tailings combined with hydrometallurgical tailings and commercial gypsum:

- Yield stress tests
- Viscosity tests
- Thickening tests.

The results of the geotechnical testwork on the samples of floatation tailings combined with hydrometallurgical tailings and commercial gypsum indicate that:

- The particle density of the tailings is estimated to be approximately 2.67 t/m^3.
- The tailings have approximately 83% and 17% passing the 75 μm and 2 μm sieve sizes, respectively.
- The tailings have a plasticity index of 14% with a liquid limit of 28%, which classifies it as low plasticity clay (CL) according to the USCS classification system.
- The tailings are likely to achieve a settled dry density of 0.9 t/m^3 under the supernatant pond (if deposited at a solids concentration of 45% w/w) that will increase to approximately 1.45 t/m^3 under a load of 600 kPa (equivalent to about 30 m of overlying material).
- The tailings are likely to achieve a minimum dry density of 1.4 t/m^3 beyond the supernatant pond (i.e. across the beaches) during summer and winter after a drying time of approximately 10 and 14 days, respectively.

- The addition of gypsum significantly enhances the removal of suspended solid from the tailings.
- The permeability of the tailings is likely to be in the order of 10^{-8} m/s to 10^{-9} m/s.

The results of the rheological testwork on the sample of floatation tailings combined with hydrometallurgical tailings and commercial gypsum indicate that:

- The BASF Magnafloc 5250 is the flocculant with the best performance in terms of free tailings settling rate and overflow water clarity.
- The optimum feed solid concentration is 5% by mass; above this optimum feed solid concentration, the settling performance decreases.
- Centrifugal pumps can pump to a solids content of approximately 63% w/w in case flocculants are added to the tailings. If a mixing tank is used to break down the floc formed during the thickening process, tailings could be pumped using centrifugal pumps up to a solid content of 67% w/w.
- At solids concentration of 67-68% w/w, the yield stress of the tailings indicates behaviour typical of paste tailings.
- The tailings can be thickened to a solid concentration in the range of 57%-59% w/w using FLSmidth high rate thickener.
- The tailings can be thickened to a solid concentration in the range of 65%-68% w/w using FLSmidth deep cone thickener.

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1.0 INTRODUCTION

Golder Associates Pty Ltd (Golder) has been engaged by Northern Minerals Pty Ltd (Normin) to provide consulting services to undertake preliminary options studies for tailings management at the Browns Range Project, located approximately 180 km southeast of Halls Creek in Western Australia.

Golder has carried out geotechnical and rheological laboratory testing on tailings samples to characterise and estimate the behaviour of the tailings during dewatering, transporting and once deposited to a dedicated TSF. The testing was undertaken in accordance with our proposal reference number P37645055-001-R-Rev0 (dated 18 July 2013) on tailings samples provided by Normin.

Golder is currently carrying out geochemical characterisation of the tailings. The results of this characterisation will be presented in a separate document once completed.

2.0 BACKGROUND

The Browns Range Project comprises several deposits of Xenotime (yttrium orthophosphate – YPO_4) and other “heavy” rare earth minerals, as well as some “light” rare earths. Normin currently envisages a process that will involve crushing/grinding the ore, floatation and/or magnetic separation to produce a rare earth concentrate, containing total rare earth oxides (TREO). The process plant is expected to generate two main streams of tailings for a total amount of 590 000 tonnes of tailings per annum (tpa). Approximately 95% (560 500 tpa) of the total amount of tailings will be generated in a beneficiation plant and the remaining 5% (29 500 tpa) in a hydrometallurgical plant. The stream of tailings generated in the hydrometallurgical plant is expected to be mildly radioactive. Current estimates indicate a life of mine of at least 10 years, which will generate a total of approximately 5.9 Mt of tailings.

Three options for the treatment of the ore at the beneficiation plant have been considered by Normin as potential candidate.

- Option 1 will generate tailings at a floatation plant (Float tailings)
- Option 2 will generate tailings at a magnetic separation plant (Mag tailings)
- Option 3 will generate about 20% Float tailings and 80% Mag tailings

These options were discussed by Golder and Normin during a meeting held on 30 October 2013. During the meeting, Normin informed Golder that, for this stage of the study, Option 1 is the preferred beneficiation option. The selection of the preferred option was made by Normin on the basis of the shortage of experience in Australia with such a magnetic separation facility.

The beneficiation plant is expected to transport the tailings to a tailings treatment plant in slurry form at a solids concentration by mass of 45% (mass of solids/total mass).

At the hydrometallurgical plant, five additional tailings streams will be generated as cake residues, as follows.

1) Gas scrubber waste (GSW) tailings, predominantly gypsum ($CaSO_4.xH_2O$)
2) Waste leach residue (WLR) tailings, which is expected to comprise 80% silica dioxide and the remaining 20% is expected to consist of iron and thorium phosphates, uranium and aluminium compounds
3) Conditioning residue (CR) tailings, which is expected to contain predominantly iron and thorium phosphates
4) Ion exchange residue (IXR) tailings, which is expected to contain uranium and thorium compounds
5) Oxalate residue (OXR) tailings, which is expected to contain oxalate compounds generated from reactions with oxalic acid at the re-precipitation plant.

The IXR and OXR tailings will be generated at the waste water treatment plant.

For the tailings characterisation Normin provided Golder the following tailings streams for testing:

- Beneficiation tailings:
  - Float tailings
  - Mag tailings
- Hydrometallurgical tailings:
  - WLR tailings
  - CR tailings
  - Waste water residue (WWR) tailings (representative of the combined IXR and OXR tailings streams).

Normin and Golder agreed to use commercially available gypsum as substitute of the GSW tailings, as at this stage of the study GSW is not available.

Due to the expected presence of radionuclides in the hydrometallurgical tailings, the separate storage of beneficiation and hydrometallurgical tailings will likely require rigorous environmental scrutiny from the authorities prior to gaining approval. Therefore, Golder and Normin agreed to omit the option of disposing the beneficiation and hydrometallurgical tailings separately. As such, the majority of the testing has been carried out on samples of floatation tailings combined with hydrometallurgical tailings and commercial gypsum. The combined sample was prepared in accordance with the mass balance provided to Golder by Normin in an email dated 17 October 2013 (refer to Section 4.2).

3.0 SCOPE OF WORK

This report has been prepared to summarise the results of the geotechnical and rheological testing carried out by Golder on samples of tailings provided by Normin. The scope of the laboratory testing was to characterise the tailings and to investigate their behaviour during dewatering, transporting and once deposited to a dedicated TSF.

The following geotechnical tests were carried out on samples of Float, Mag and hydrometallurgical (Hydromet) tailings:

- Particle size distribution (PSD)
- Specific gravity (SG) of particles.

The following geotechnical tests were carried out on samples of Float tailings combined with Hydromet tailings and commercial gypsum:

- Atterberg limits test
- Consolidation tests: settling tests, slurry consolidometer, drying tests (air, summer and winter cycles drying tests)
- Permeability tests.

The following rheological tests were carried out on samples of Float tailings combined with Hydromet tailings and commercial gypsum:

- Yield stress tests
- Viscosity tests

- Thickening tests.

The tests were carried out by qualified laboratory technicians at the Golder laboratory in Osborne Park.

4.0 TAILINGS SAMPLES PREPARATION

4.1 Samples delivery

On 9 August 2013, Normin delivered two drums of 200 L capacity containing Float and Mag tailings to Golder's Perth laboratory.

- One drum containing approximately 200 L of Float tailings at 17% solid content by mass
- One drum containing approximately 100 L of Mag tailings at 37% solid content by mass

On 16 October 2013, ALS delivered to Golder's Perth laboratory a bucket containing four bags of solids samples (Hydromet tailings) and one containing 20 L of treated waste water (TWW). Normin informed Golder that the Hydromet tailings were oven dried at 100°C by ALS to perform moisture content testing prior being delivered to Golder laboratory.

The total dry mass of Hydromet tailings provided by ALS was 2.55 kg. The mass of each individual Hydromet tailings streams were the following:

- 1000 g of WLR
- 200 g of CR
- 200 g of CR + WLR combined
- 950 g of WWR

The TTW has not been used for undertaking the geotechnical and rheological testing. It will be tested as part of the geochemical characterisation currently underway.

4.2 Mass balance

Normin provided to Golder the mass balance of tailings streams by email on 17 October 2013. The mass balance was estimated using the plant simulation model METSIM. The tailings mass balance is presented in Table 1.

Table 1: Tailings mass balance summary.

Unit operation	Solids mass flow (kg/h)	Percentage (%)
Beneficiation tailings	***72 832***	***95.02%***
Hydrometallurgical tailings		
GSW	517	0.67%
LR	1 626	2.12%
CR	427	0.56%
WWR	1 250	1.63%
Total hydrometallurgical tailings	***955***	***4.98%***
Total	**76 652**	**100%**

The GSW was substituted with commercial gypsum, which was purchased from Sibelco Australia Ltd.

4.3 Sample preparation

The tailings characterisation (PSD and SG tests) was performed on samples of Float, Mag and Hydromet tailings. The Hydromet tailings sample was prepared combining the WLR, CR and LR tailings in accordance with the proportions presented in Table 1. The remaining geotechnical and rheological tests were undertaken by combining the Float tailings with the Hydromet tailings and commercial gypsum (FHG tailings). The FHG tailings sample was prepared to a solid content by mass of approximately 45% (% w/w).

The FHG tailings preparation procedure consisted of the following steps:

1) The Float tailings were oven dried at 50°C to increase its solid content from ~17% w/w to ~45% w/w.

2) The correct amount of each individual Hydromet tailings streams and commercial gypsum were successively added to the Float tailings slurry to generate the FHG tailings, using the mass balance proportions presented in Table 1.

3) The tailings were finally mixed for approximately 30 min using an IKA mixer at ~700 revolutions per minute (rpm) to homogenise the sample (see Figure 1).

4) Additional deionised water was added to the FHG tailings to undertake the rheological tests where a solid content lower than 45% w/w was required. Conversely, the FHG tailings sample was further oven dried at 50°C to undertake the rheological tests if a solid content above 45% w/w was needed.

Figure 1: Typical mix FH tailings procedure (step 3).

5.0 BENEFICIATION TAILINGS PRELIMINARY SETTLING OBSERVATIONS

5.1 Float and Mag tailings supernatant comparison

Preliminary settling tests were undertaken by Golder to compare the settling properties of the Float and Mag tailings. The tailings in the Float and Mag tailings drums were firstly mixed; two samples were then extracted from each drum for conducting preliminary settling test. Figure 2 shows the settling behaviour of the two types of beneficiation tailings after a period of approximately 24 hours. The Mag tailings show a clear supernatant water, with negligible suspended solids. Conversely, the Float tailings was characterised by three distinct sedimentation zones: a solid zone at the bottom of the container, a supernatant zone with high concentration of suspended solids above it and a thin layer of supernatant with low concentration of suspended solids at the very top of the container.

Figure 2: Floatation tailings settling (left); magnetic tailings settling (right).

A similar condition was observed inside the Float and Mag tailings drums after the slurry was left settling undisturbed for more than 1 month. Figure 3 shows two samples of supernatant water extracted from the Float tailings drum and one sample extracted from the Mag tailings drum after a settling period of 1 month.

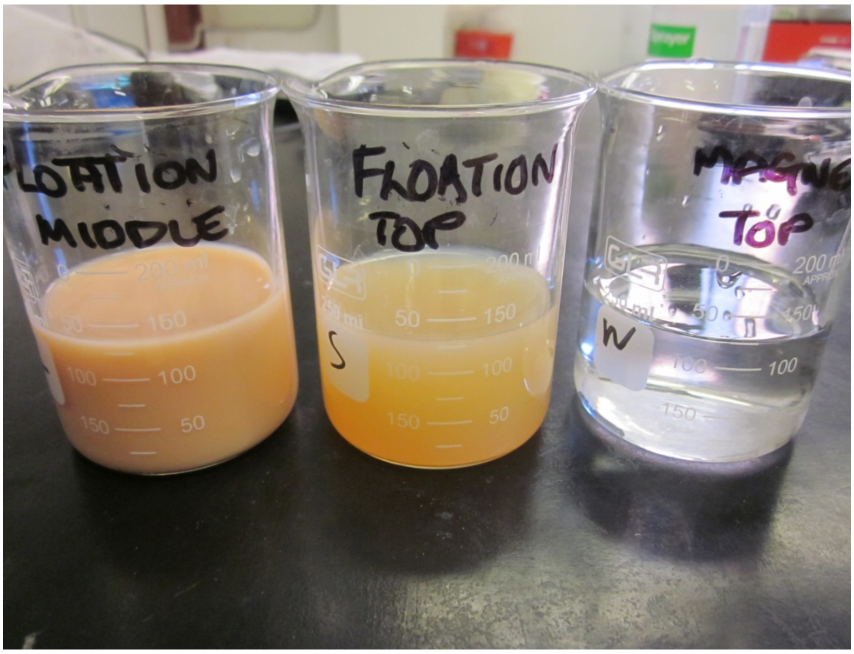

Figure 3: Float tailings supernatant (left and middle beaker); Mag tailings supernatant (right beaker).

The samples shown at the left and at the centre of Figure 3 are representative of the supernatant water inside the Float tailings drum. The sample at the centre of the figure was extracted at approximately 5 mm from the top of the drum; the sample at the left was extracted at the middle of the drum. The sample shown at the right of Figure 3 is indicative of the typical supernatant water inside the Mag tailings drum.

The two samples extracted from the Float tailings drum were dried at 100 °C to measure the amount of suspended matter: the amount of solids in the first 5 mm of the floatation tailings drum was approximately 0.23% w/w; the suspended solids in the sample extracted at the middle of the drum was approximately 4.15% w/w.

It is clear that the magnetic tailings present a supernatant clear of suspended solids; conversely, the Float tailings showed the presence of suspended solids in the supernatant at a measured concentration of approximately 4% w/w.

5.2 Removal of the Float tailings suspended solids by addition of gypsum

The presence of suspended solids in the Float tailings is likely the result of an excessive negative charge on the surface of the particles in suspension due to the chemical agents used at the floatation plant for the recovery of the rare earth minerals. This negative surface charge causes the repulsion of particles in solution creating a non-settling suspension. The non-settling nature of a suspension is dependent on the intensity of the "electrical double layer" surrounding the particles, which consists of the negative charge of the colloids and the positive charge of cations present in solution.

The two most significant mechanisms affecting the colloidal properties are the concentration and nature of the free cations, and the solution pH. The coagulation of the suspended solids can be enhanced by adding an agent that contains cations (Al^{+3}, Ca^{+2}, Na^{+}). The higher the valence of the cations, the greater will be the propensity to form colloids. Gypsum (Ca_2SO_4) is a coagulation agent that releases calcium (Ca^{2+}) in solution; the calcium reduces the forces of repulsion between negative charged particles, hence forming colloids. The inclusion of the GSW tailings, which is predominantly pure gypsum, will therefore be essential to produce a clear supernatant water from the total tailings.

Figure 4 shows the effect that the addition of commercial gypsum has to the presence of suspended solids in the Float tailings supernatant. Figure 4 demonstrates that the coagulation of the suspended solids in the Float tailings is significantly enhanced by adding commercial gypsum (approximately 1% by mass).

Figure 4: Float tailings supernatant water after the addition of gypsum.

6.0 TAILINGS GEOTECHNICAL CHARACTERISATION

6.1 Characterisation tests

6.1.1 Purpose and test method

The PSD is a benchmark test that provides an indication of how the tailings are likely to behave after placement. If the tailings have a large amount of clay-sized particles, the tailings may exhibit a low permeability and be subject to strength loss due to the formation of excess pore pressures during loading. Additionally, the PSD allows comparison to other tailings, providing an indication of the relative field performance. The PSD was performed by wet screening for the soil fraction from 106 µm to 10 000 µm and by Sedigraph (X-ray absorption) for the fraction from 0.3 µm to 106 µm.

The SG is a key parameter used throughout typical tailings characterisation tests and design calculations. It is used in most standard soil mechanics equations and is required for calculations used in other tests (e.g. consolidation tests). The SG was performed in accordance with ASTM D2854.

6.1.2 Results and interpretation

The results of the classification tests carried out are summarised in Table 2. Laboratory test certificates are included in Appendix A. For comparison purposes, the PSDs are presented graphically in Figure 5.

Table 2: Summary of classification tests of Float, Mag and Hydromet tailings

Test	Parameter	Float tailings	Mag tailings	Hydromet tailings
Particle Density	SG (-)	2.68	2.79	2.47
Particle Size Distribution	Sand (2 mm to 75 µm) (%)	18	6	9
	Fines (<75 µm) (%)	82	94	91
	Fines Clay size (<2 µm) (%)	17	28	8

Table 3: Summary of classification tests of FHG tailings

Test	Parameter	FHG tailings
Particle Density	SG (-)	2.67(*)
Particle Size Distribution	USCS**	CL (low plasticity clay)
	Sand (2 mm to 75 µm) (%)	17
	Fines (<75 µm) (%)	83
	Fines Clay size (<2 µm) (%)	17
Atterberg Limits	Liquid Limit (LL) (%)	28
	Plastic Limit (PL) (%)	14
	Plasticity Index (PI) (%)	14
	Linear Shrinkage (LS) (%)	3

*Gypsum particle density assumed to be 2.3. Combined SG estimated by mass balance; **Unified Soil Classification System

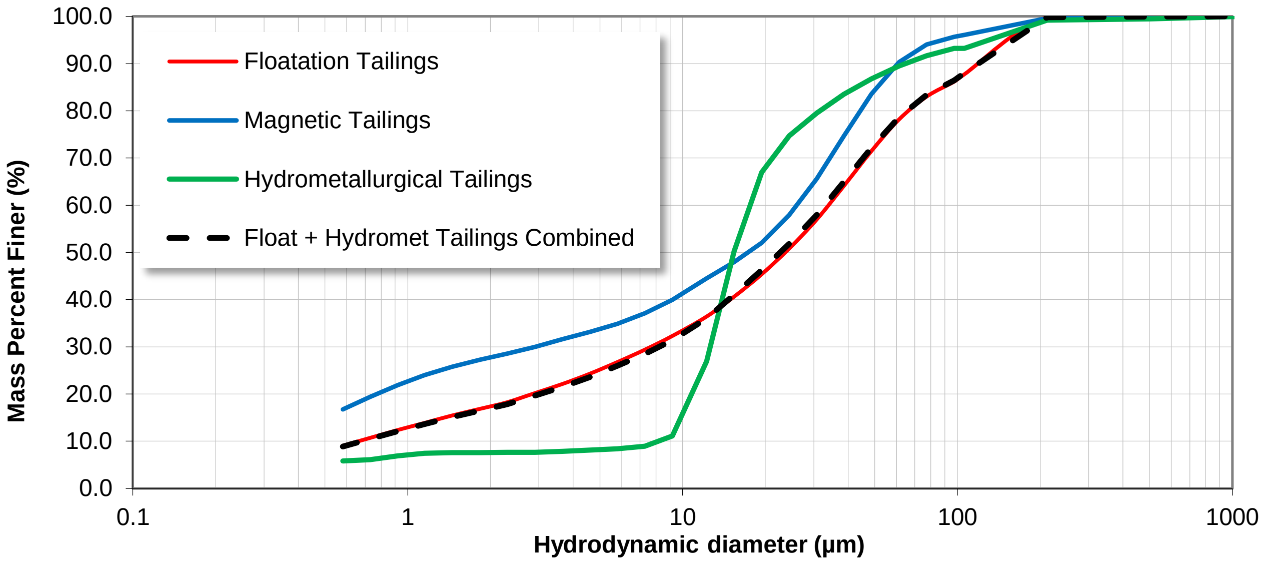

Figure 5: Tailings PSD (data from 106 µm to 1000 µm by wet screening, from 0.3 µm to 106 µm by sedimentation)

The results of the characterisation tests indicate that the Float tailings contain more sand size particles than the Mag and Hydromet tailings. Conversely, the Mag and Hydromet tailings contain more fines below 75 µm than the Float tailings. The Hydromet tailings contain the greatest amount of fines below 2 µm.

The PSD of the Float tailings combined with the Hydromet tailings was synthesised using the mass balance presented in Table 1. Figure 5 shows that the PSD of the Float and Hydromet tailings combined is nearly identical to the PSD of the Float tailings. This is due to the proportion of Hydromet tailings being so low (4.31% of the total tailings generated, excluding the GSW) and thus not significantly influencing the shape of the Float tailings PSD.

The results of the characterisation test indicate that the FHG tailings is a low plasticity tailings (plasticity index of 14%), with a liquid limit of 28%. The USCS classifies the FHG tailings as low plasticity clay (CL).

6.2 Settling tests

6.2.1 Purpose and test method

The settling tests were carried out to evaluate the rate of settling and to estimate the initial deposited dry density likely achieved by the FHG tailings. An in-house laboratory procedure that is regularly used for tailings samples of this type was adopted for the settling tests.

The following settling tests were carried out:

- Top and bottom undrained
- Top drained and bottom undrained
- Top undrained and bottom drained
- Top and bottom drained.

The samples were placed into four different cylinders at a solids concentration by weight (Cw) of approximately 45% w/w. This solids content was selected assuming the scenario in which tailings will be deposited at the TSF following being thickened to 45% w/w at the process plant (i.e. assuming that no further dewatering occurs prior deposition). In the event that the tailings are further dewatered, the results of the settling tests would represent a conservative estimate of the initial tailings density achieved at the TSF.

The undrained settling test simulates the case in which the tailings are placed over a low permeability material (e.g. a liner) and remained submerged (e.g. beneath the supernatant pond). The top drained settling test simulates the case in which the tailings are not submerged but still placed over a low permeability material.

The bottom drained settling test simulates the case in which the tailings are placed over a higher permeability material (e.g. a liner overlaid by a drainage layer, or on natural ground of higher permeability than the tailings) but remained submerged (e.g. beneath the supernatant pond). The top and bottom drained settling test simulates the case in which the tailings are not submerged and placed over a higher permeability material.

To simulate the bottom drained and the undrained scenarios, water is allowed to drain from the bottom of the cylinders. In the top drained tests, water is removed from the top of the cylinder.

6.2.2 Results and interpretation

The laboratory test certificates for the settling tests are provided in Appendix A

Figure 6 shows the results of settling tests for the FHG tailings. The following outcomes are indicated by the following results.

- The maximum dry density measured in the settling tests ranges from approximately 0.8 t/m^3 to approximately 1.0 t/m^3.

- The drained and undrained settling densities are dissimilar. This shows that the presence of a higher permeability layer beneath the TSF is likely to improve the consolidation of the tailings.
- The top drained and top undrained tests settling densities are similar. This shows that the initial settling density of the tailings is not affected by the presence/absence of water at its surface.
- The settling density measured in the bottom drained tests reaches a constant (and maximum) density after approximately 7 days.
- The settling density measured in the bottom undrained tests reaches a constant (and maximum) density after approximately 4 days.

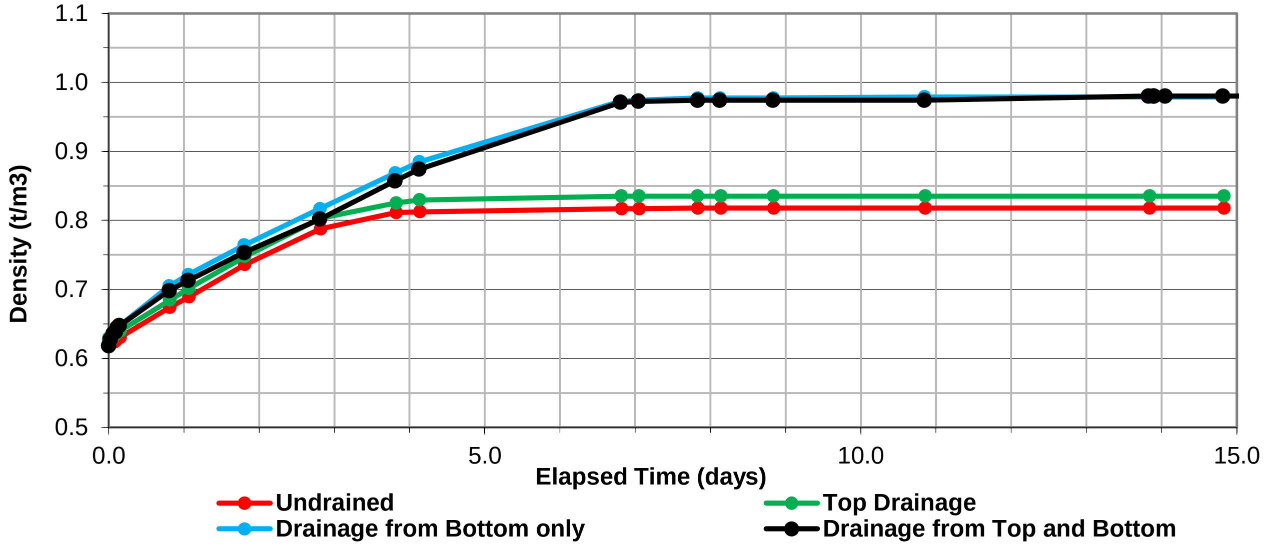

Figure 6: FHG tailings settling tests – dry density (t/m^3) versus time (days).

Figure 7 shows the settling column during the testing period.

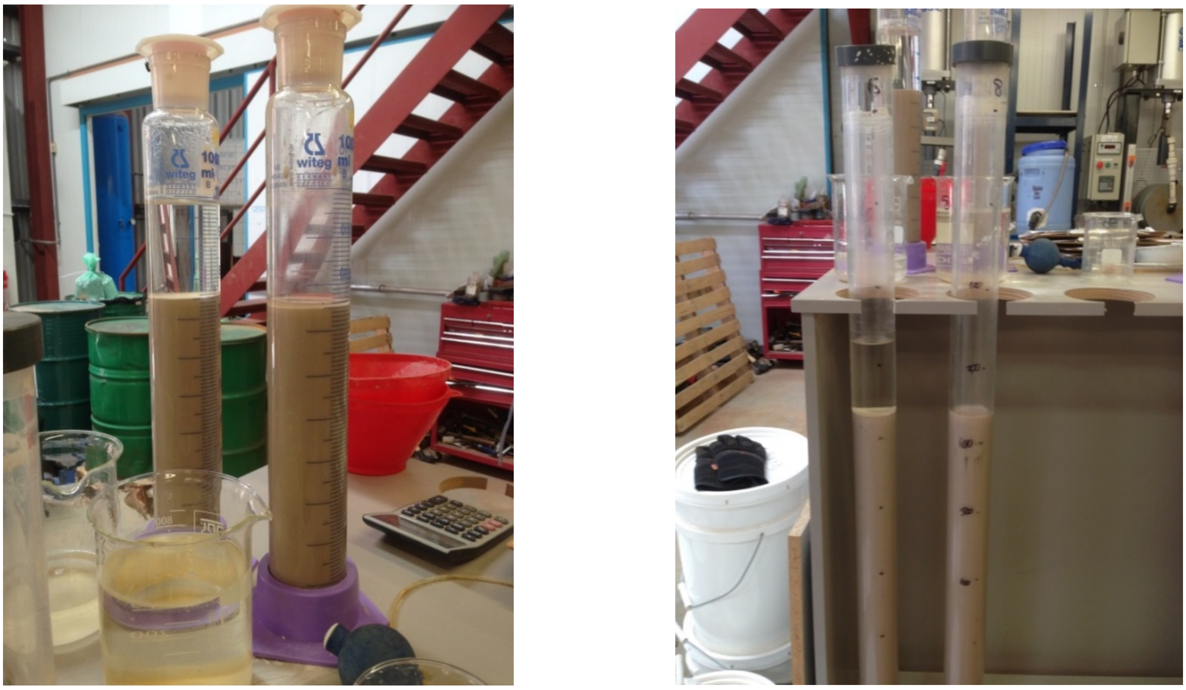

Figure 7: FHG tailings undrained and top drained tests (left); bottom drained and top/bottom drained tests (right).

6.3 Drying tests

6.3.1 Purpose and test method

Air drying, winter and summer cycles tests provide an indication of the drying behaviour of the tailings in the areas of the TSF not submerged by water (away from the supernatant pond, across the beaches). The tests allow the estimation of tailings dry density outside the supernatant pond area. This is essential to size the TSF, to understand if the tailings are likely to be normally or over-consolidated under imposed loads, and to estimate the allowable rate of rise.

Samples of FHG tailings were placed into containers at a solids concentration of approximately 45% w/w to perform the air, winter and summer drying tests. Consistent with the settling tests, this solids content was selected assuming the scenario in which tailings will be deposited at the TSF following being thickened to 45% w/w at the process plant (i.e. assuming that no further dewatering occur prior deposition). In the event that the tailings are further dewatered, the results of the drying tests would be conservative.

In the air drying tests, the sample is allowed to dry under ambient laboratory temperature. During the testing period, tube samples are taken from the container to measure moisture and dry density.

The winter and summer drying tests are used to investigate the effect that temperature variations have on drying of the tailings. To simulate the drying of the tailings during winter, the tailings sample was placed in a refrigerator during night at a temperature of 7°C and allowed to dry under ambient laboratory temperature (about 25°C) during the day. To simulate the drying of the tailings during summer, the tailings sample was allowed to dry under ambient laboratory temperature during the day and placed in the oven at a maximum temperature of 33°C overnight. During the drying period, the weight of the sample was measured to estimate its moisture content. The winter-summer tests dry density is finally assessed using a dry density – moisture content fit line curve, which is estimated from the air drying test result.

6.3.2 Results and interpretation

The laboratory test certificate for the drying test is provided in Appendix A and the results of the air drying test are summarised in Table 4, and presented graphically in Figure 8.

The tube density test results indicate that the tailings have settled to a maximum dry density of 1.48 t/m^3 after approximately 25 days and reached a dry density of approximately 1.40 t/m^3 after approximately 17 days. Figure 8 shows that at approximately 36% moisture content the tailings start de-saturating (leaving the zero air void line). The trend line presented in Figure 8 was adopted to estimate the dry densities in the winter – summer cycle tests.

Table 4: Summary of tube density air drying test

Elapsed time (Days)	Moisture Content (%)	Dry density (t/m^3)
0	119	0.64
7	51	1.14
10	43	1.25
14	36	1.37
17	27	1.39
21	18	1.43
25	5	1.48

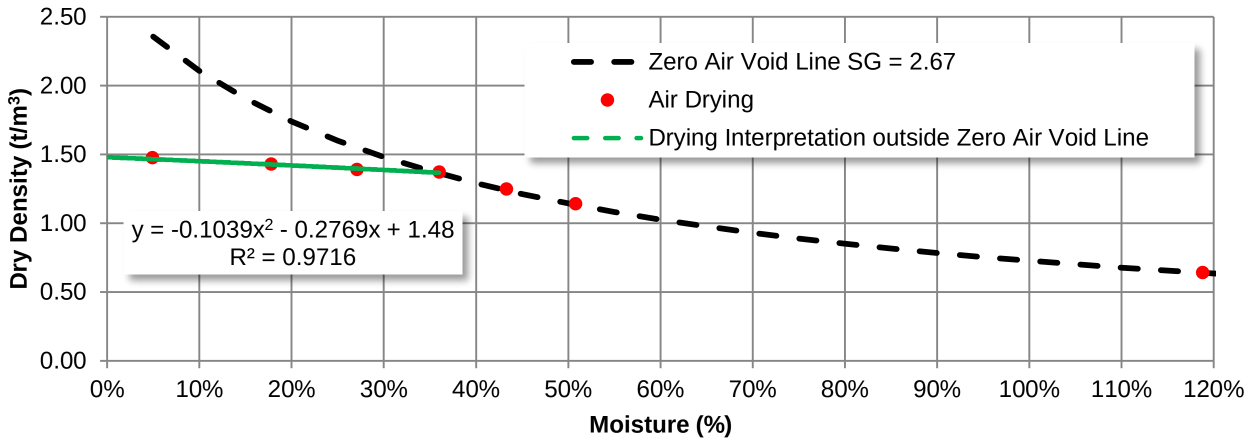

Figure 8: Air drying moisture content – dry density relationship.

The result of the winter and summer drying test are presented in Figure 9 and Figure 10. Figure 9 and Figure 10 show that a minimum dry density of 1.40 t/m^3 at 20% moisture content (approximately 70% saturation) can be achieved during summer and winter in approximately 10 to 14 days, respectively.

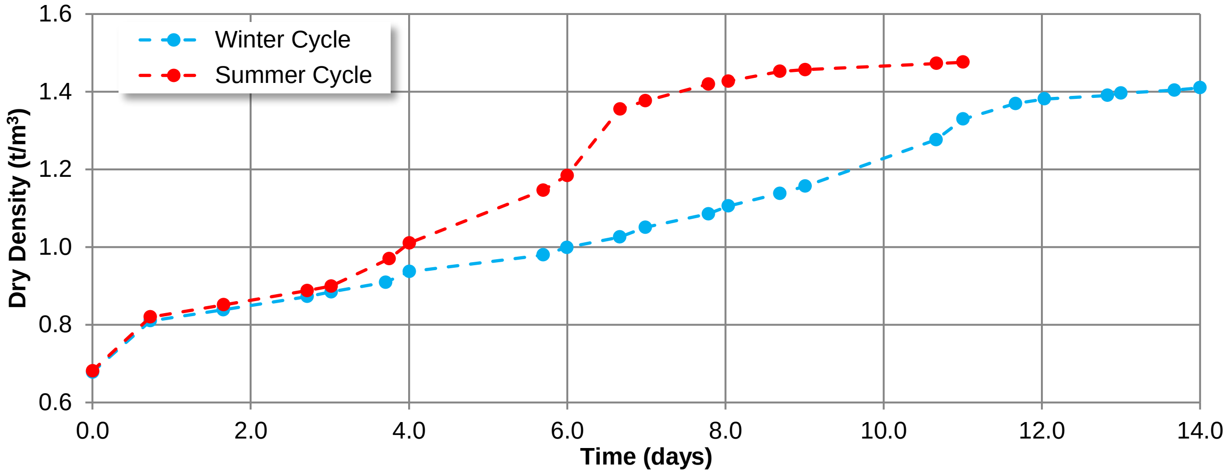

Figure 9: Winter and summer cycle dry density versus time.

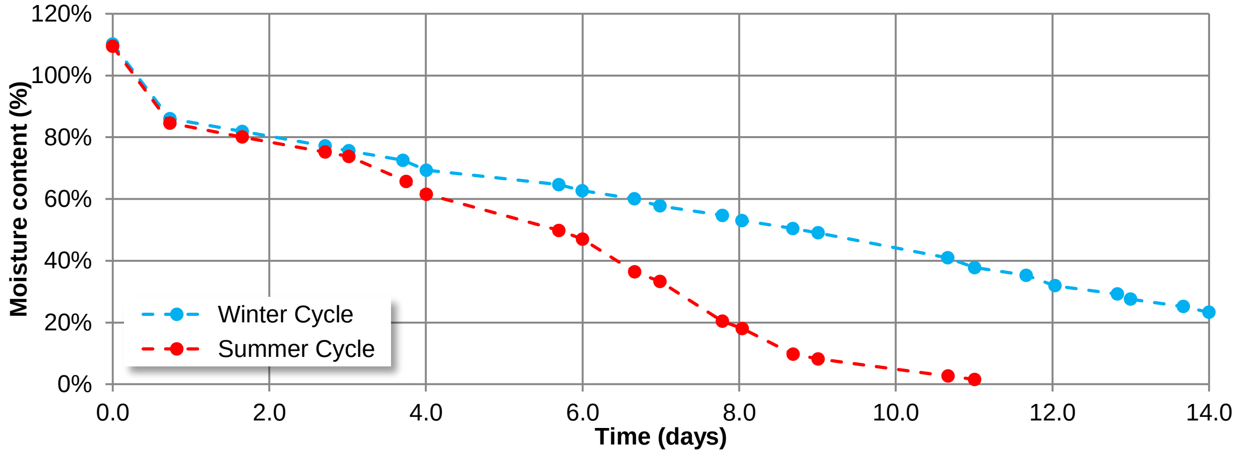

Figure 10: Winter and summer cycle moisture content versus time.

Figure 11 and Figure 12 show the air drying test and winter-summer cycle tests during the testing period.

Figure 11: Air drying test after approximately 14 days of drying period.

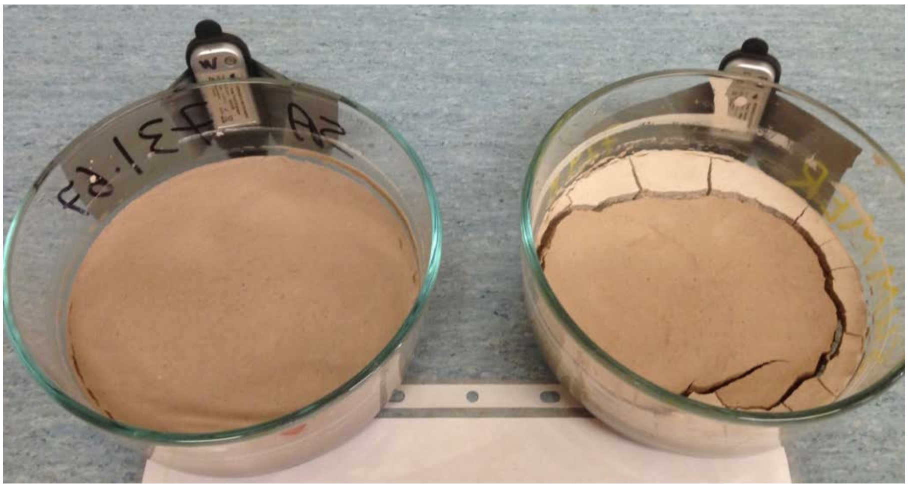

Figure 12: Winter cycle (left) and summer cycle (right) tests.

6.4 Slurry consolidation tests

6.4.1 Purpose and test method

The consolidation properties of the tailings are an important design parameter, used both for design of a facility, as well as to provide an indication of the tailings behaviour post-closure. The design of a TSF requires an understanding of the dry density that is likely to be achieved under various loads, as well as the time required to achieve it. In addition, to establish the overall footprint, is essential to size required for the TSF it is necessary to estimate the allowable tailings rate of rise.

A consolidation test was carried out on the FHG tailings using a slurry consolidometer. The slurry consolidometer is similar to a conventional oedometer, in that a load is applied vertically, but the sample is allowed to drain in one direction, vertically upwards. A pressure transducer is fitted at the bottom of the apparatus that allows the measurement of the pore water pressure within the sample. Unlike a conventional oedometer, the slurry consolidometer can accommodate slurry poured into the mould.

Once the sample is placed in to the cell, the load on the sample is increased in stages with the excess pore pressure generated by the load allowed to dissipate before the next load is placed. The rate that the pore pressures dissipate (and hence the rate of consolidation) is inversely related to the permeability of the sample (which decreases as the pore size gets smaller, i.e. as the sample compresses). Readings of the amount of settlement (and pore water pressure) over time are recorded until the excess pore pressure dissipates (i.e. the tailings consolidates). The load is then increased and the process repeated for each loading cycle. The final loading should be somewhat greater than the maximum load anticipated in the field.

A sample of FHG tailings was placed into the cell at a solids concentration of approximately 45% w/w. The test was run applying vertical loading in six stages from 20 kPa to 600 kPa.

Constant head permeability tests were undertaken on the sample at different vertical loading prior applying the next load. The constant head permeability tests are discussed in Section 6.5.

6.4.2 Results and interpretation

The laboratory test certificate for the slurry consolidometer test is provided in Appendix A and Figure 13 presents the results of the slurry consolidometer tests. Best fit lines that represent the mathematical relationship between the void ratio and the vertical effective pressure are provided. The graph shows that both a power-fit line and the alternative fit line represent the results accurately. These mathematical relationships are adopted in estimating the normally consolidated dry density of tailings using large strain consolidation models. Figure 13 also shows that the void ratio of the tailings ranged from 2.4 during the initial loading of the sample to 0.86 when the sample was loaded with a vertical effective stress of 600 kPa.

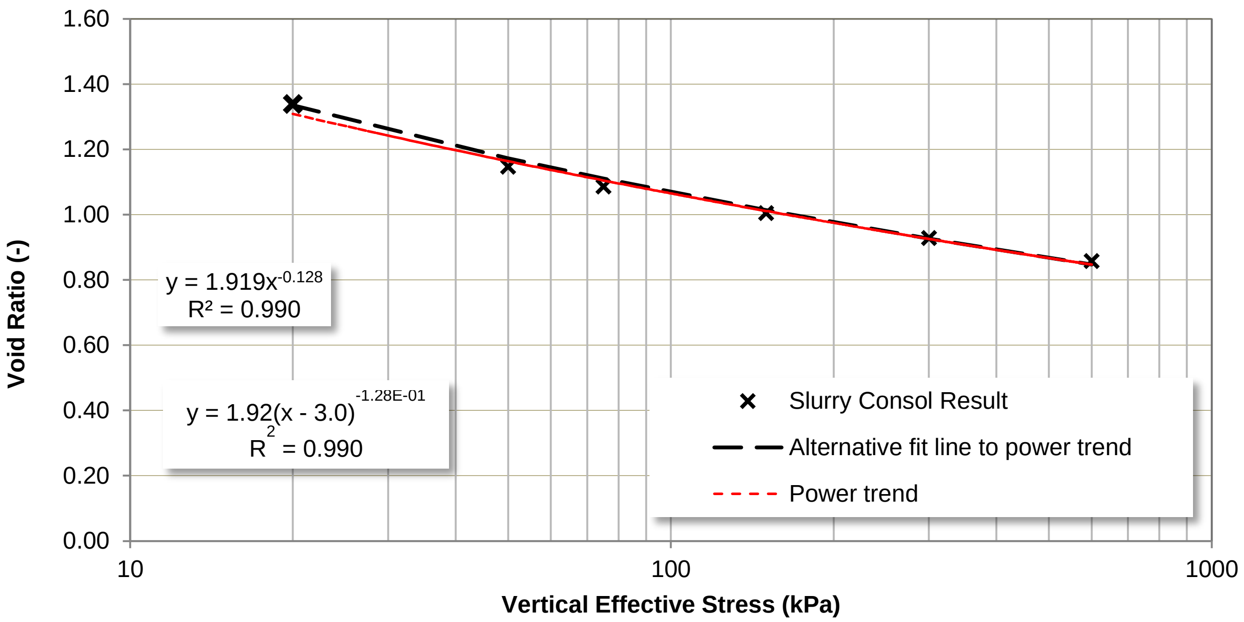

Figure 13: Void ratio versus effective stress results from consolidation test.

Figure 14 shows the dry density achieved during the slurry consolidometer test for different vertical loading. The dry density reaches a maximum value of ~1.45 t/m^3 at a vertical effective stress of 600 kPa.

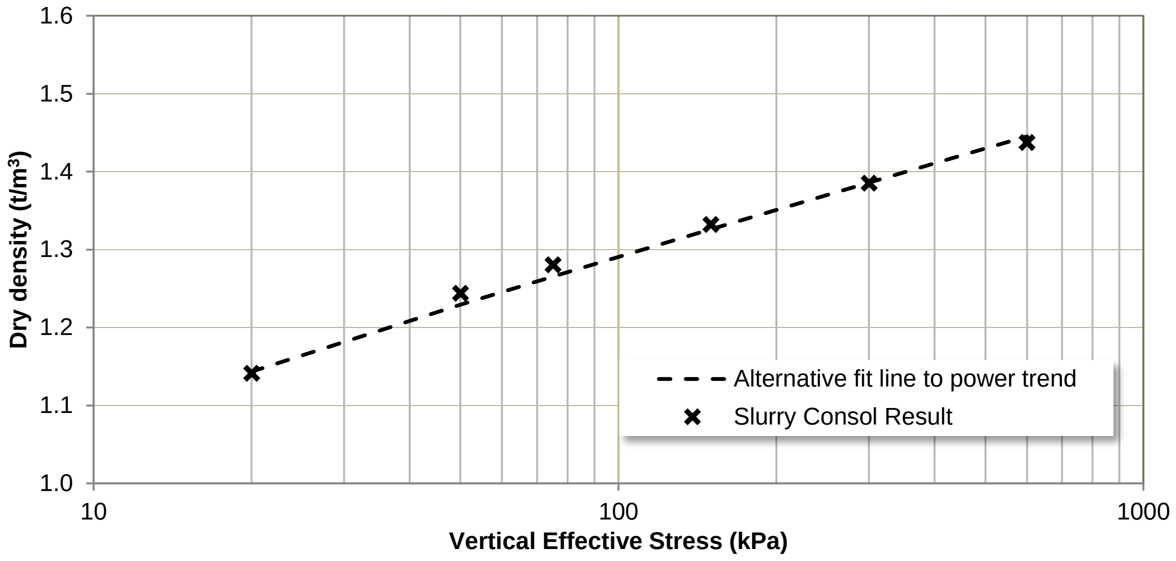

Figure 14: Dry density versus vertical effective stress trend estimated from the void ratio vs vertical effective stress alternative fit line.

After being deposited at the TSF, tailings will first settle to an initial dry density, then dry in the areas away from the supernatant pond and/or consolidate as a result of loading arising from further tailings deposition. As result of this deposition cycle, the tailings dry density will vary through its depth. The dry density will increase from its initial settled dry density (at the supernatant pond) or air dried density (away from the supernatant pond) at the surface, to a final dry density (which is a function of the maximum height of material overlain the tailings) at the bottom. Therefore, depending on the rate of rise, tailings will follow the normal consolidation line (NCL) shown in Figure 13 and Figure 14 at the supernatant pond.

Away from the supernatant pond, the tailings are expected to dry to a density of 1.4 t/m^3 (refer to Section 6.3), and will remain over-consolidated until approximately 19 m of saturated (or near saturation) tailings are deposited (corresponding to a vertical effective stress of approximately 350 kPa). If, for instance a further 6 m of air dried tailings are deposited atop, the bottom layer of tailings will further consolidate, following the NCL to a maximum density of 1.42 t/m^3 (corresponding to a vertical effective stress of approximately 460 kPa). The tailings will likely achieve a dry density of ~1.45 t/m^3, if they are overlain by approximately 30 m of saturated (or near saturation) tailings.

6.5 Permeability Tests

6.5.1 Purpose and test method

Permeability tests were carried out to estimate the tailings permeability at different dry densities, representing different vertical effective pressures. The tailings permeability governs the release of seepage from the tailings and its consolidation rate under an imposed load. It is an important parameter used both in consolidation and seepage analysis.

Constant head permeability tests were carried out on the sample of FHG tailings at different vertical loads prior applying the next load. The permeability tests were undertaken in the slurry consolidometer in general accordance with AS 1289 6.7.3.

A falling head permeability test was carried out on the sample of FHG tailings used to undertake the top and bottom drained settling test (refer to Section 6.2.2). The test was performed to estimate the permeability of the top layer of tailings. The test was completed by allowing a head of water to flow through the sample. These are the expected initial drainage conditions of the tailings once deposited.

6.5.2 Results and interpretation

The laboratory test certificate for the constant and falling head permeability tests are provided in Appendix A and Figure 15 presents the results of the permeability tests.

The permeability of the tailings at different vertical effective stresses ranged from approximately 1.0×10^{-7} m/s at a dry density of approximately 0.98 t/m^3 (falling head permeability test), to approximately 5.0×10^{-9} m/s at a dry density of approximately 1.44 t/m^3 (constant head permeability test in the slurry consolidometer).

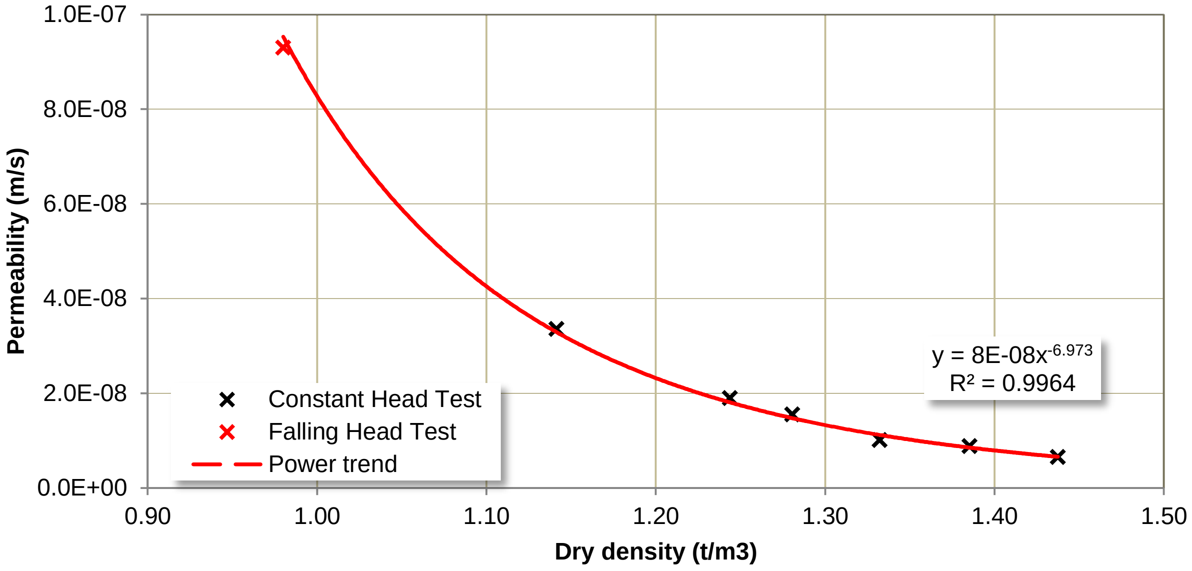

Figure 15: Dry density versus permeability trend line and test results.

7.0 TAILINGS RHEOLOGICAL CHARACTERISATION

7.1 Yield stress and viscosity test

7.1.1 Purpose and test method

The yield stress and viscosity tests were carried out on samples of FHG tailings to provide an indication of the tailings dewatering and pumping characteristics, and tailings behaviour once deposited to a dedicated TSF.

The rheological tests were undertaken in a Haake VT550 Rheometer. The Haake VT550 Rheometer is a speed controller rotational viscometer manually or remotely controlled by an external computer. The resistance of the fluid against an applied speed is measured by the deflection of a torsion bar. The rheological properties of the fluid (shear stress, shear rate and viscosity) are recorded in the computer.

The yield shear stress of the tailings at different solid content by mass can be estimated by measuring its static shear stress with a shear vane. The static shear vane test involves slowly rotating a vane immersed in the tailings and measuring the resulting torque as a function of time. The torque (fluid resistance force) is finally converted to shear stress (fluid resistance pressure) by applying a conversion factor that accounts for the shape and size of the vane. The yield shear stress is the maximum shear stress estimated in the test.

The viscosity of a fluid is defined as the ratio of shear stress (Pa) to the shear rate (s^{-1}) applied. A fluid can be characterised by the relationship between shear stress and shear rate. The trend between shear stress and shear rate is called “rheogram”. Newtonian fluids exhibit a linear rheogram (constant viscosity), while non-Newtonian fluids exhibit a non-linear rheogram (non-constant viscosity). The viscosity is an important parameter used to assess the pumping requirements and frictional losses in a pipe for the tailings transportation or the beach slope of the tailings once deposited to a dedicated TSF. In the viscosity test, the shear vane is substituted with a rotating bob. The viscosity test involves rotating a bob immersed in the tailings at different rate of shear and measuring the resulting torque. The torque is finally converted to shear stress.

The tests were carried out on samples of FHG tailings at a solid content by mass from approximately 50% (slurry consistency) to 70% w/w (paste consistency) in order to gather the full range of rheological parameters required to investigate the behaviour of the tailings during dewatering and transport.

A sample of Float tailings (previously prepared at solid content by mass of 45%) was oven dried at 50°C overnight and mixed with Hydromet tailings and commercial gypsum based on the proportions presented in Table 1. The mixed samples (FHG tailings) were then placed in beakers of one litre capacity. If required, the solid content by mass of the samples was adjusted by adding deionised water. Prior to commencing the test, the sample was homogenised by hand stirring for 30 seconds.

The static yield stress tests were performed using a shear rate of 0.104 s^{-1}. The viscosity tests were carried out using shear rates from 7 s^{-1} to 500 s^{-1}. Five different solids concentrations were tested for yield stress and five different solids concentration were tested to generate rheograms.

The test programme was controlled by the rheological software Rheowin v4.30.

7.1.2 Results and interpretation

Yield stress

The laboratory test certificate for the yield stress tests are provided in Appendix A. Five samples of the FHG tailings were tested at the following solids concentrations by mass: 59.1%, 64.6%, 66.4%, 69.1%, and 70.9%. The summarised yield stress curves are shown in Figure 16.

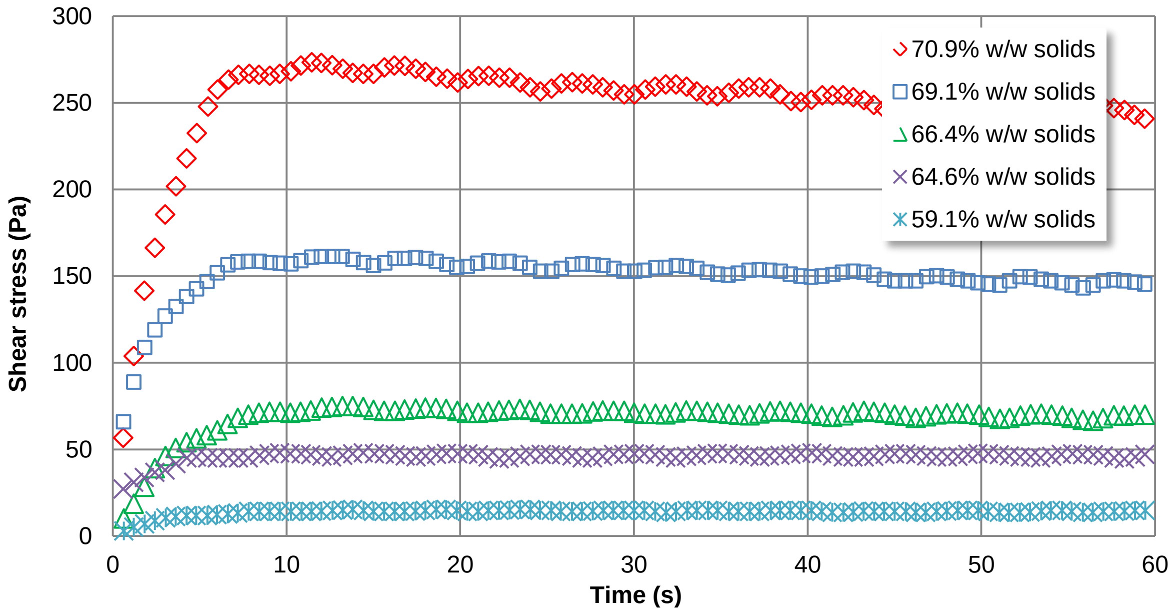

Figure 16: Yield stress curve for FHG tailings samples

The following observations are indicated by the results:

- For samples below 64.6% w/w solids concentration, the samples showed signs of settling.
- The tailings samples with lower solids concentration showed faster settling rates than samples with higher percentage of solids.
- The tailings sample at 57% solids concentration segregates quite fast, such that the vane yield stress test could not be performed.

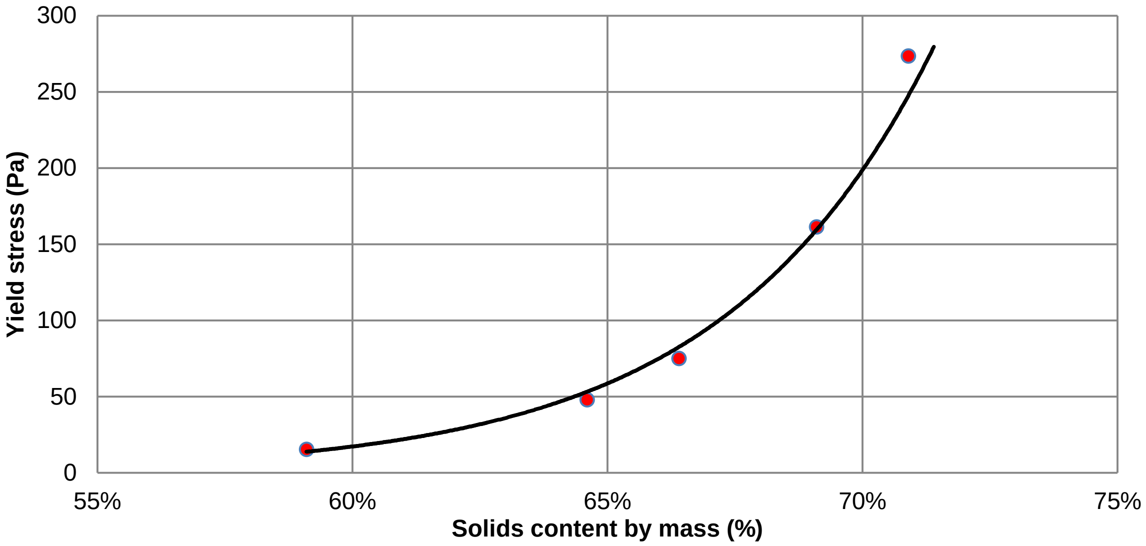

Figure 17: Yield stress against percentage of solids

Figure 17 indicates that as solids concentration increases, the yield stress increases exponentially reaching a value of approximately 75 Pa at approximately 66% w/w. This solids content (hence yield stress) indicates the limit at which the tailings can be pumped using centrifugal pumps. At solids concentration of 67- 68% w/w, the yield stress of the tailings indicates behaviour typical of what is commonly described as 'paste' tailings.

Viscosity test

The laboratory test certificate for the viscosity tests are provided in Appendix A. Five samples of the FHG tailings were tested at the following solids concentrations by mass: 61%, 59%, 57%, 55%, and 49%. The rheograms are shown in Figure 18.

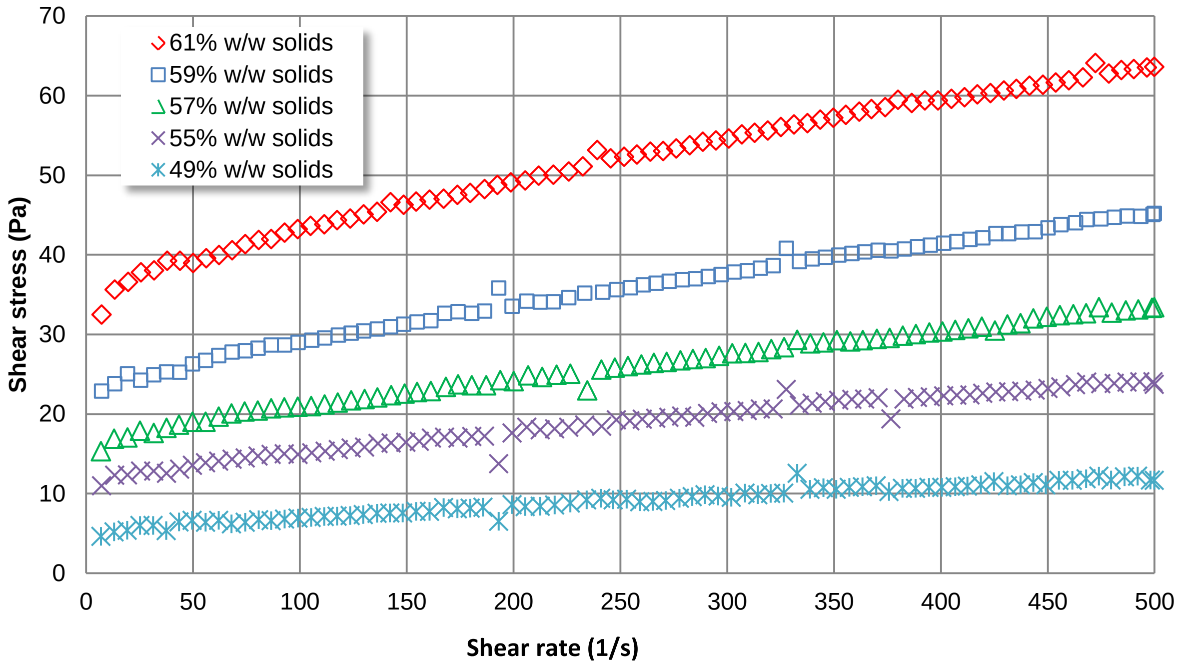

Figure 18: Rheogram of FHG tailings samples at carious solids concentration

The Herschel-Bulkley model accurately suits a fluid with a yield stress that exhibits non-linear viscous behaviour. This model is used to fit the experimental data measured in the viscometer by the calibration of three rheological parameters: yield stress, flow consistency and behaviour index. The equation for the Herschel-Bulkley model is presented below:

$$\tau = \tau_y + K\dot{\gamma}^n$$

Where:

τ is the shear stress (Pa)

$\dot{\gamma}$ is the shear rate (s^{-1})

τ_y is the yield stress (Pa)

K is the fluid consistency index ($Pa.S^n$)

n is the flow behaviour index.

The Herschel-Bulkley rheological model was applied to the rheogram. The fitting of Herschel-Bulkley parameters to the rheograms was executed by inscribing a curve over each set of data presented in Figure 18, with the equation of each curve following the format of the Herschel-Bulkley equation. A typical Herschel-Bulkley model fit is presented in Figure 19, in this case for the solids concentration of 61% w/w. For each curve, values for the τ_y, *K* and *n* were selected to provide the best fit to the experimental data. These values were then plotted against the solids concentration value in Figure 20.

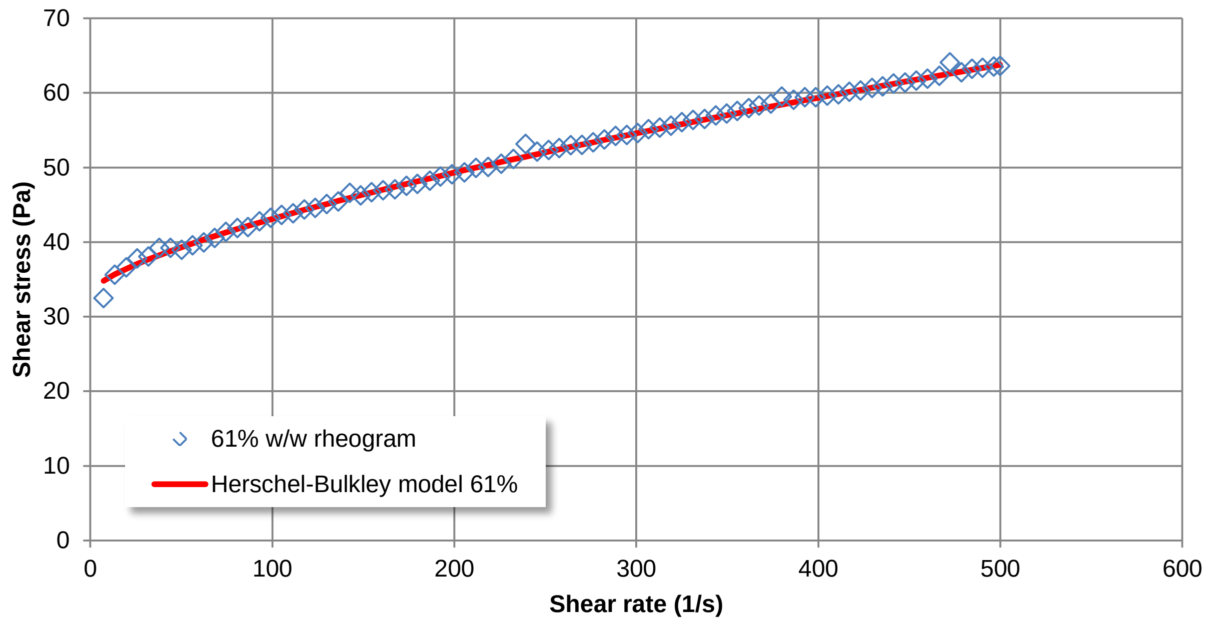

Figure 19: Herschel-Bulkley model for FHG tailings sample at 61% solids concentration

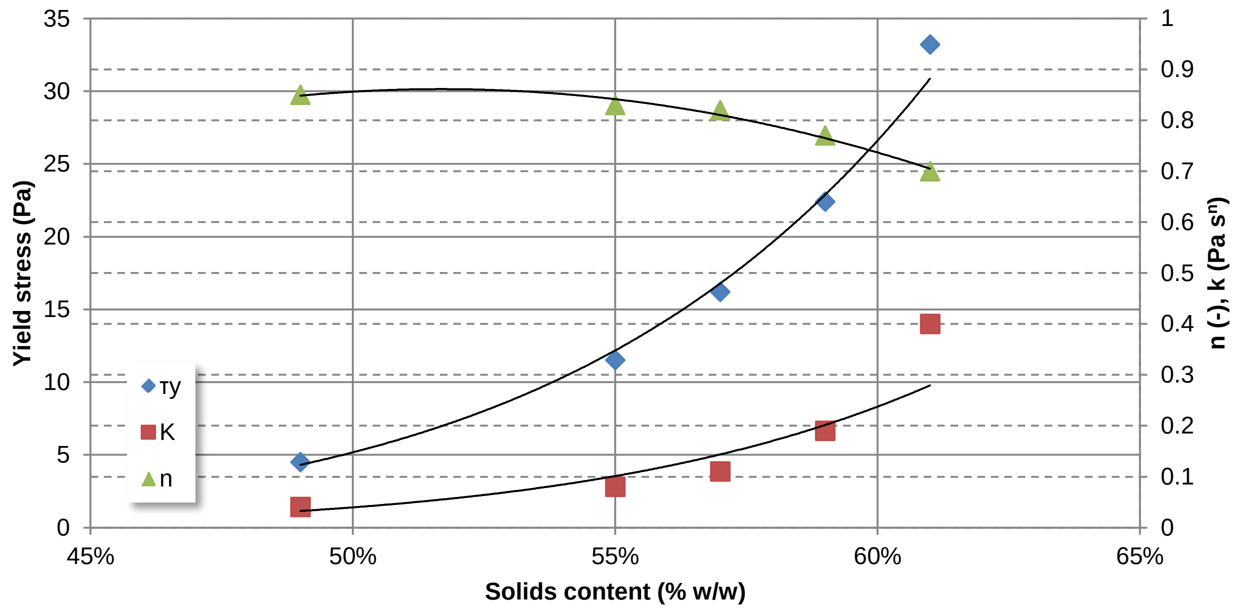

Figure 20: Herschel-Bulkley parameter fits as a function of tailings slurry concentration

Table 5 summaries the estimated yield stress from the Herschel-Bulkley model fitted to the rheograms and the measured yield stress from the vane yield stress tests.

Table 5: Summary of estimated and vane yield stress at different solids concentrations

Solids concentration (% w/w)	Estimated yield stress (From Herschel-Bulkley model) (Pa)	Vane yield stress results (Pa)
71	-	273.3
69	-	161.3
66	-	75.0
65	-	47.9
61	33.2	-
59	22.4	15.2
57	16.2	-
55	11.5	-
49	4.5	-

There is a slight difference between the estimated yield stress and vane yield stress for 59% w/w solids concentration. Due to observed settling behaviour during the yield stress measurement for 59% w/w, the measured yield stress value for 59% w/w could be inaccurate.

Centrifugal pumps can pump tailings slurries with yield stresses up to approximately 80 Pa. Based on the test carried out, this corresponds to a solids concentration of approximately 67% w/w. For solids concentrations above 67% w/w, the results indicate that positive displacement pumps are likely required to transport the tailings.

7.2 Thickening tests

7.2.1 Purpose and test method

Thickening tests were carried out on samples of FHG tailings to provide an indication of the size of high rate and deep cone paste thickeners to thicken the tailings to optimum underflow solids. The thickening tests were carried out by FLSmidth Pty Ltd (FLSmidth). Due to the radioactive nature of the tailings, the tests were performed at the Golder laboratory in Osborne Park, which is licensed by the Western Australian Radioactive Council to handle radioactive material.

The sample was prepared by Golder to an initial solid content 45% w/w. Deionised water was added to the tailings by FLSmidth technician, if tailings at solids content lower than 45% w/w were required. Conversely, the sample was oven dried at 50°C overnight, if tailings at solids content above 45% w/w were needed.

Settling tests were initially undertaken to assess the optimal flocculant required to thicken the tailings. The flocculant investigated were BASF Magnafloc 10, 155, 5250, 919 and 800HP. Subsequently, static cylinder settling tests, continuous fill deep tube settling tests and filter leaf tests were performed on the tailings to size the thickeners.

The thickener underflow yield stress was obtained using a Haake VT550 with a custom made (by FLSmidth) vane sensor.

7.2.2 Results and interpretation

The FLSmidth testwork report for the thickening test is provided in Appendix B: "*Report of investigation into the thickening of Browns Range rare earth mineral tailings*" for Northern Minerals, dated November 2013.

The results of the thickening tests indicate that:

- The BASF Magnafloc 5250 is the flocculant with the best performance in terms of free tailings settling rate and overflow water clarity.
- The optimum feed solid concentration is 5% by mass; above this optimum feed solid concentration, the settling performance decreases.
- The tailings can be thickened to a solid concentration in the range of 57%-59% w/w using high rate thickener.
- The tailings can be thickened to a solid concentration in the range of 65%-68% w/w using deep cone thickener.

Table 6 summarised the yield stress reported by FLSmidth and measured by Golder. The underflow yield stress values are significantly higher than the yield stress obtained by Golder. This is due to the use of flocculant during the thickening process. It is envisaged that with a rapid shear (i.e. by mixing), the floc formed during the thickening process will likely break down, reducing the tailings yield stress. Therefore, the sheared underflow yield stress would be similar to no flocculant added yield stress for transportation purpose (similar to Golder static yield stress test, refer to Section 7.1).

Table 6: FLSmidth and Golder yield stress results comparison

Solids concentration (% w/w)	Estimated yield stress (From Herschel-Bulkley model) (Pa)	Vane yield stress (Pa)	FLSmidth Thickener underflow yield stress (Pa)
71	-	273	500
70	-	-	381
69	-	161	281
68	-	-	228
67	-	-	186
66	-	75	148
65	-	48	116
64	-	-	87
63	-	-	75
62	-	-	63
61	33	-	51
60	-	-	43
59	22	15	35
58	-	-	25
57	16	-	22
56	-	-	18
55	12	-	-
49	5	-	-

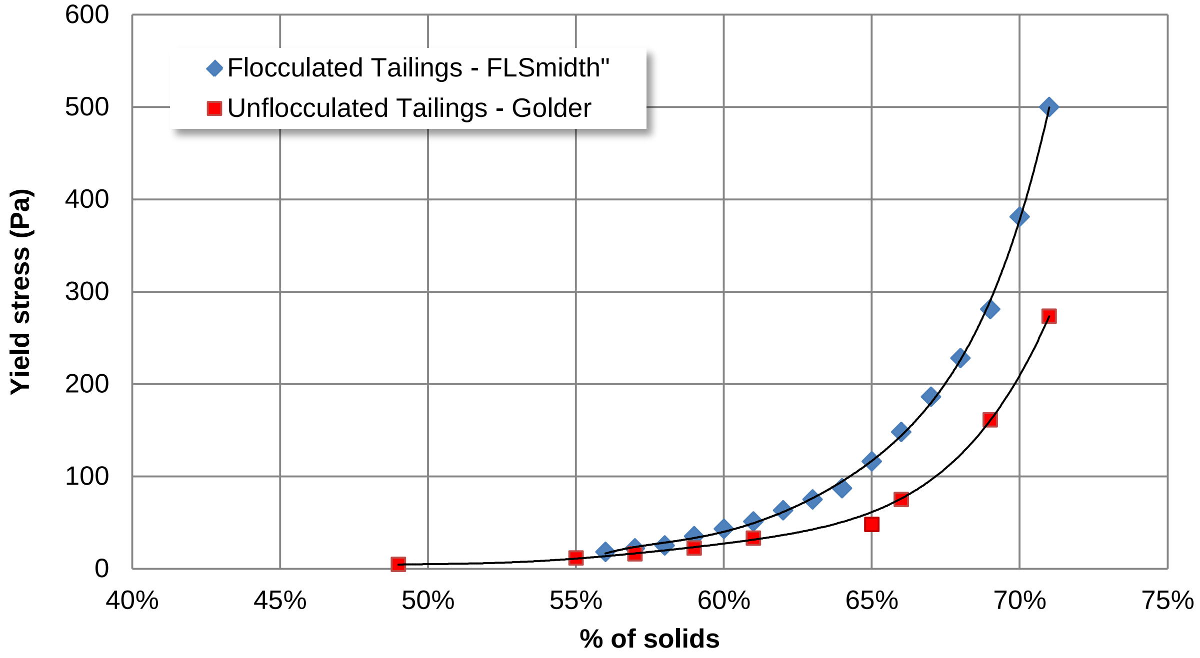

Figure 21: Underflow yield stress (FLSmidth) and no flocculant added yield stress (Golder) comparison

8.0 CONCLUSIONS AND DISCUSSION

The laboratory testing programme has been carried out to provide an indication of the behaviour of the tailings when dewatered, transported and deposited to a dedicated TSF. The results of the geotechnical testwork on the tailings samples indicate that:

- Gypsum significantly enhances the removal of suspended solid from the Float tailings and if the GSW tailings are comingled with the Float tailings, a satisfactory supernatant clarity is likely to result.
- The particle density of the FHG tailings is estimated to be approximately 2.67 t/m^3.
- The FHG tailings have approximately 83% and 17% passing the 75 μm and 2 μm sieve sizes, respectively.
- The FHG tailings have a plasticity index of 14% with a liquid limit of 28%, which classifies it as low plasticity clay (CL) according to the USCS classification system.
- The FHG tailings are likely to achieve at the supernatant pond a settled dry density of 0.9 t/m^3 (if deposited to a solid concentration of 45% w/w) that will increase to approximately 1.45 t/m^3 under a load of 600 kPa (equivalent to about 30 m of overlying material).
- The FHG tailings are likely to achieve outside the supernatant pond a minimum dry density of 1.4 t/m^3 during summer and winter after a drying time of approximately 14 days.
- The permeability of the FHG tailings is likely to be in the order of 10^{-8} m/s to 10^{-9} m/s at different loads.

Tailings will be likely deposited to a solid content greater than 45% w/w. Therefore, the initial tailings dry density will be likely greater than the one measured in the settling test (performed at an initial solid content of 45% w/w). Figure 22 presents the hypothetical normal consolidation lines for slurry solid contents greater than 45% w/w based on the results of the settling and slurry consolidometer tests.

As shown in the figure below, the tailings not submerged by water are likely to be over-consolidated up to reaching an effective vertical pressure of approximately 350 kPa (approximately 19 m of saturated tailings).

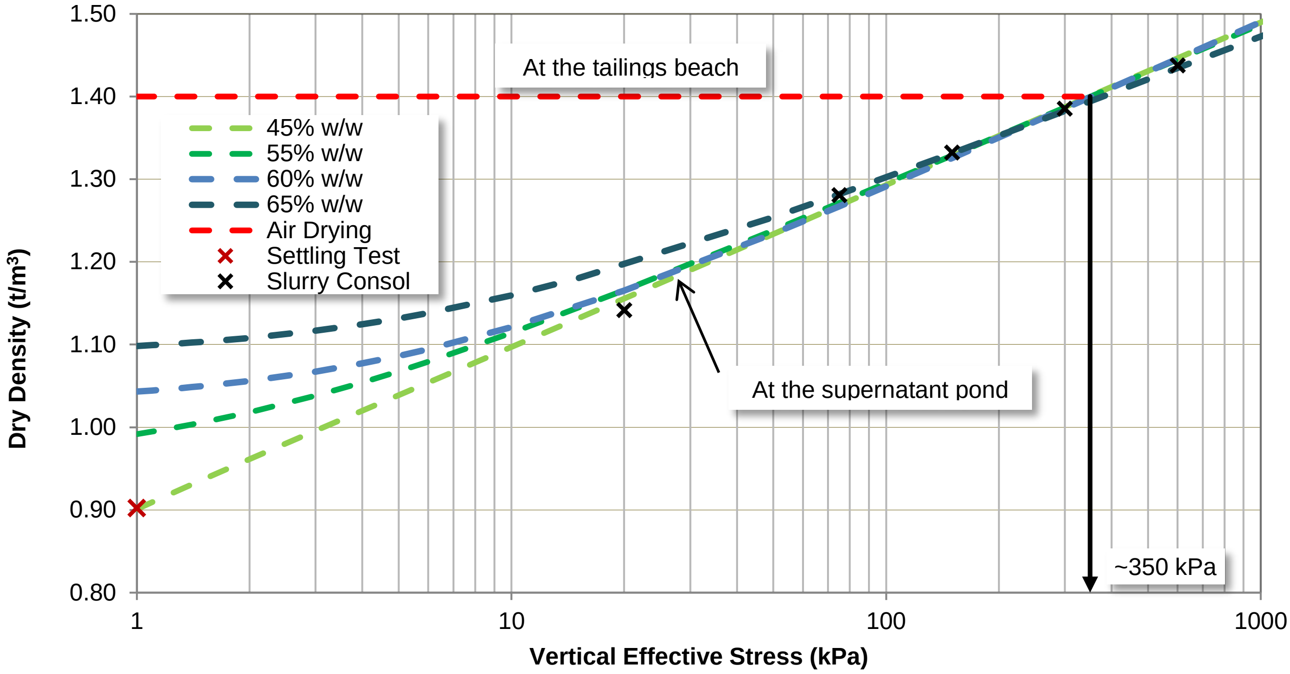

Figure 22: Dry density versus vertical effective stress at different FHG tailings solids content.

Table 7 presents the summary interpretation of the testing carried out for the FHG tailings.

Table 7: Summary of FHG tailings geotechnical properties

Property		Unit	Value
Particle density		(-)	2.67
Particle size distribution	Sand (2 mm to 75 µm)	%	17
	Fines (< 75 µm)	%	83
	Clay size (< 2 µm)	%	17
Atterberg Limits	LL	%	28
	PL	%	14
	PI	%	14
	LS	%	3
Settled density (@ 45% initial solid content)	Undrained	t/m^3	~ 0.8
	Top drainage	t/m^3	~ 0.8
	Drainage bottom only	t/m^3	~ 1.0
	Drainage from top and bottom	t/m^3	~ 1.0
Dry density in drying test	After 14 days	t/m^3	1.4
Dry density in slurry consolidometer	@ 20 kPa	t/m^3	1.14
	@ 600 kPa	t/m^3	1.44
Constant head permeability	@ 20 kPa	m/s	3.4×10^{-8}
	@ 600 kPa	m/s	6.5×10^{-9}
Falling head permeability	@ ~1.0 t/m^3	m/s	9.3×10^{-8}

The results of the rheological testwork carried out on the FHG tailings sample indicate that:

- The BASF Magnafloc 5250 is the flocculant with the best performance in terms of free tailings settling rate and overflow water clarity.
- The optimum feed solid concentration is 5% by mass; above this optimum feed solid concentration, the settling performance decreases.
- Centrifugal pump can pump to a solids content of approximately 63% w/w in case flocculants are added to the tailings. If a mixing tank is used to break down the floc formed during the thickening process, tailings could be pumped using centrifugal pumps up to a solid content of 67% w/w.
- At solids concentration of 67-68% w/w, the yield stress of the tailings indicates behaviour typical of paste tailings.
- The tailings can be thickened to a solid concentration in the range of 57%-59% w/w using FLSmidth high rate thickener.
- The tailings can be thickened to a solid concentration in the range of 65%-68% w/w using FLSmidth deep cone thickener.

9.0 LIMITATIONS

Your attention is drawn to the document “Limitations”, which is included in Appendix C of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

GOLDER ASSOCIATES PTY LTD

Riccardo Fanni	David Williams
Tailings Engineer	Principal

RF/DW/hsl

A.B.N. 64 006 107 857

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APPENDIX A

Tailings Laboratory Test Certificates

Suite 6
642 Albany Hwy
Victoria Park
WA 6100

Client: Golder Associates Pty Ltd
Job number: 13_0965
Sample: 13_ **0965_01**
Client ID: **117641004 North Star Stage**
Date: 12/9/2013
Analysis: Absolute density by helium pycnometry following ASTM D2854 – '89

Sample preparation

A representative sub-sample was taken and oven dried at 50 °C prior to analysis.

Analysis

The sample was analysed using a Micromeritics Accupyc with helium gas (99.9%). The instrument was calibrated using a NIST standard prior to the analysis. The analysis was conducted 10 times to enable an average value and standard deviation to be quoted. The analyses were conducted at 21 °C.

Summary

The density value was determined to be:

Client ID	Lab ID	Density (g/cc)
137645044 13441421 Floatation Tailings	13_0965_01	2.682 ± 0.003

microanalysis australia

Suite 6
642 Albany Hwy
Victoria Park
WA 6100

Client: Golder

Client ID: 137645044 13441421 Floatation Tailings

Job No: 13_0965

Laboratory ID: 13_0965_01

Analysis: X-ray sedimentation by Sedigraph 5100 | **Analysis temp.:** 35.7 °C

Dispersant: Water | **Sonication:** 10 min

Additives: 10 mL sodium hexametaphosphate | **Concentration:** ~5 % w/w

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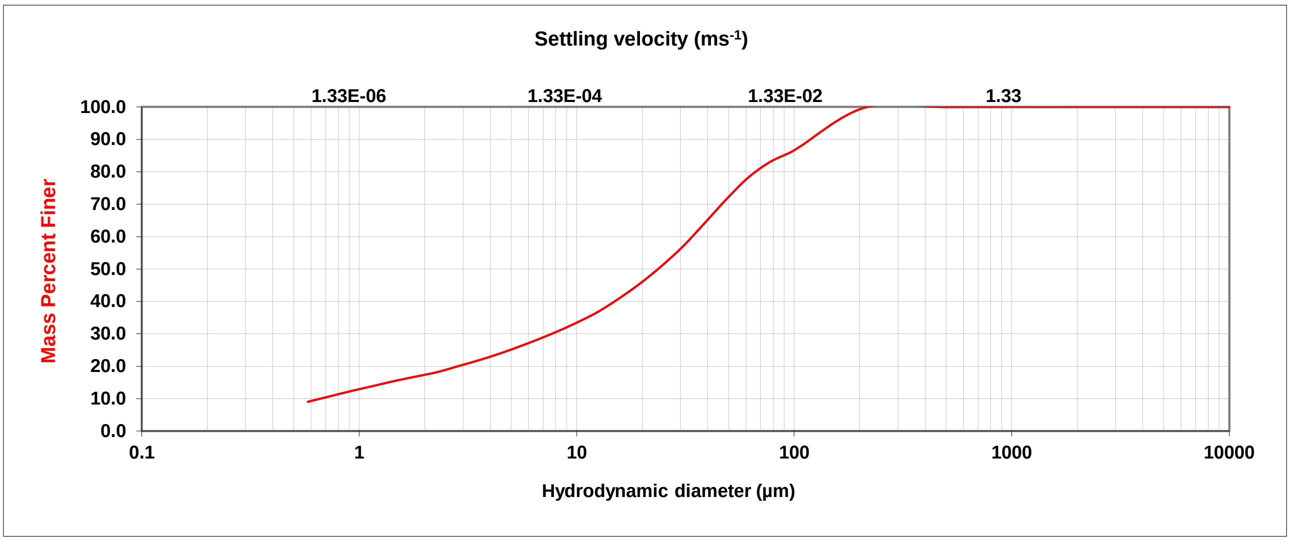
Sample density: 2.682 g/cm^3 (measured)

Liquid density: 0.994 g/cm^3 | **Critical diameter:** 53.99 µm

Liquid viscosity: 0.724 cp



Max size (µm)	Min size (µm)	In %	Mean settling velocity* (ms^{-1})	Max size (µm)	Min size (µm)	In %	Mean settling velocity* (ms^{-1})
10000.00	2000.00	0.0	1.67E+01	12.23	9.17	4.1	9.38E-05
2000.00	1000.00	0.0	1.67E+00	9.17	7.29	2.9	5.59E-05
1000.00	500.00	0.0	4.18E-01	7.29	5.79	2.6	3.53E-05
500.00	212.00	0.1	8.87E-02	5.79	4.60	2.5	2.23E-05
212.00	106.00	12.1	1.88E-02	4.60	3.65	2.2	1.40E-05
106.00	97.16	1.6	8.62E-03	3.65	2.90	1.9	8.85E-06
97.16	77.18	3.2	6.27E-03	2.90	2.30	1.9	5.58E-06
77.18	61.31	4.8	3.96E-03	2.30	1.83	1.4	3.52E-06
61.31	48.70	6.7	2.50E-03	1.83	1.45	1.4	2.22E-06
48.70	38.68	7.4	1.58E-03	1.45	1.15	1.6	1.39E-06
38.68	30.73	7.2	9.94E-04	1.15	0.92	1.5	8.85E-07
30.73	24.41	6.1	6.27E-04	0.92	0.73	1.7	5.62E-07
24.41	19.39	5.4	3.96E-04	0.73	0.58	1.7	3.54E-07
19.39	15.40	4.7	2.50E-04	0.58	0.10	9.0	4.85E-08
15.40	12.23	4.2	1.58E-04	Total:		100.0	

Note : Data from 106 µm to 10,000 µm by wet screening , from 0.3µm to 106 µm by Sedimentation.

* based on the mean of the size interval and on the the calculations and variables in the 'settling velocity worksheet

Suite 6
642 Albany Hwy
Victoria Park
WA 6100

Client: **Golder Associates Pty Ltd**
Job number: 13_1052
Sample: **13_1052_01**
Client ID: **1137645044 13441422 Magnetic Tailings**
Date: 9/10/2013
Analysis: Absolute density by helium pycnometry following ASTM D2854 – '89

Sample preparation

A representative sub-sample was taken and oven dried at 50 °C prior to analysis.

Analysis

The sample was analysed using a Micromeritics Accupyc with helium gas (99.9%). The instrument was calibrated using a NIST standard prior to the analysis. The analysis was conducted 10 times to enable an average value and standard deviation to be quoted. The analyses were conducted at 21 °C.

Summary

The density value was determined to be:

Client ID	Lab ID	Density (g/cc)
1137645044 13441422 Magnetic Tailings	13_ 1052_01	2.786 ± 0.004

microanalysis australia

Suite 6
642 Albany Hwy
Victoria Park
WA 6100

Client: Golder

Client ID: 13764504413441422Magnetic Tailings

Job No: 13_1052

Laboratory ID: 13_1052_01

Analysis: X-ray sedimentation by Sedigraph 5100

Dispersant: Water

Additives: 10 mL sodium hexametaphosphate

Analysis temp.: 35.7 ºC

Sonication: 10 min

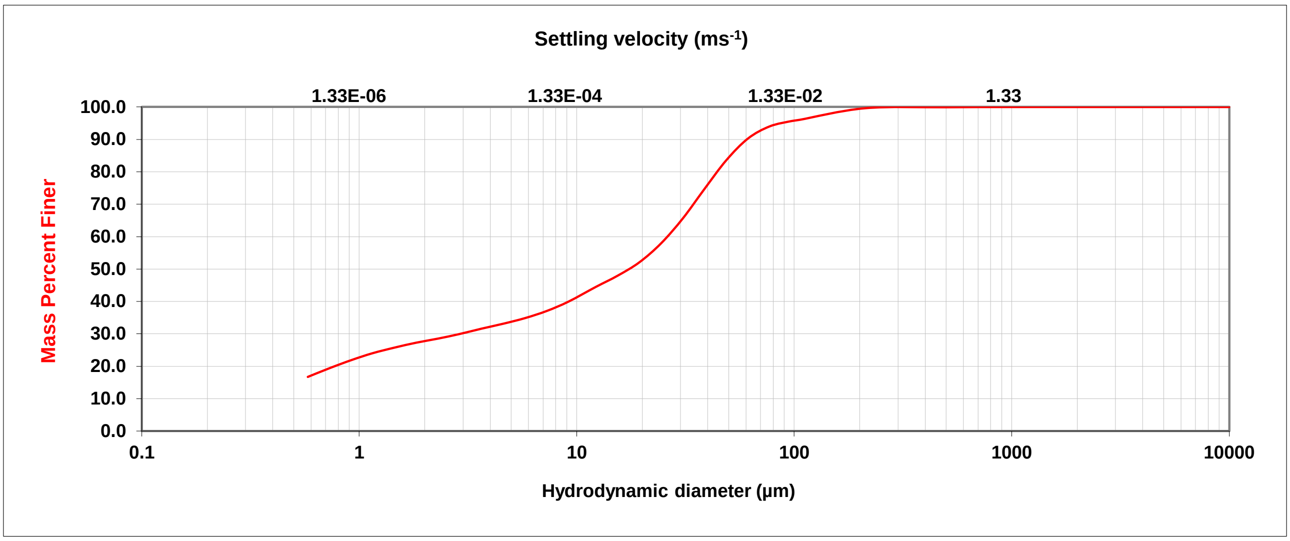
Concentration: ~5 % w/w

Sample density: 2.786 g/cm^3 (measured)

Liquid density: 0.994 g/cm^3

Liquid viscosity: 0.724 cp

Critical diameter: 52.94 µm



Max size (µm)	Min size (µm)	In %	Mean settling velocity* (ms^{-1})	Max size (µm)	Min size (µm)	In %	Mean settling velocity* (ms^{-1})
10000.00	2000.00	0.0	1.78E+01	12.23	9.17	4.5	9.97E-05
2000.00	1000.00	0.0	1.78E+00	9.17	7.29	2.9	5.94E-05
1000.00	500.00	0.1	4.44E-01	7.29	5.79	2.2	3.75E-05
500.00	212.00	0.3	9.42E-02	5.79	4.60	1.7	2.37E-05
212.00	106.00	3.6	2.00E-02	4.60	3.65	1.5	1.49E-05
106.00	97.16	0.4	9.15E-03	3.65	2.90	1.6	9.41E-06
97.16	77.18	1.6	6.66E-03	2.90	2.30	1.4	5.93E-06
77.18	61.31	3.7	4.21E-03	2.30	1.83	1.2	3.74E-06
61.31	48.70	6.7	2.65E-03	1.83	1.45	1.5	2.36E-06
48.70	38.68	8.8	1.67E-03	1.45	1.15	1.7	1.48E-06
38.68	30.73	9.1	1.06E-03	1.15	0.92	2.1	9.40E-07
30.73	24.41	7.7	6.67E-04	0.92	0.73	2.5	5.97E-07
24.41	19.39	5.9	4.21E-04	0.73	0.58	2.7	3.76E-07
19.39	15.40	4.1	2.65E-04	0.58	0.10	16.7	5.15E-08
15.40	12.23	3.5	1.67E-04	Total:		100.0	

Note : Data from 106 µm to 10,000 µm by wet screening , from 0.3µm to 106 µm by Sedimentation.
* based on the mean of the size interval and on the the calculations and variables in the 'settling velocity worksheet

Suite 6
642 Albany Hwy
Victoria Park
WA 6100

Client: **Golder Associates**
Job number: 13_1212
Sample: **13_ 1212_01**
Client ID: **137645044 13441826**
Date: 15/11/2013
Analysis: Absolute density by helium pycnometry following ASTM D2854 – '89

Sample preparation

A representative sub-sample was taken and oven dried at 50 °C prior to analysis.

Analysis

The sample was analysed using a Micromeritics Accupyc with helium gas (99.9%). The instrument was calibrated using a NIST standard prior to the analysis. The analysis was conducted 10 times to enable an average value and standard deviation to be quoted. The analyses were conducted at 21 °C.

Summary

The density value was determined to be:

Client ID	Lab ID	Density (g/cc)
137645044 13441826	13_1212_01	2.473 ± 0.015

microanalysis australia

Suite 6
642 Albany Hwy
Victoria Park
WA 6100

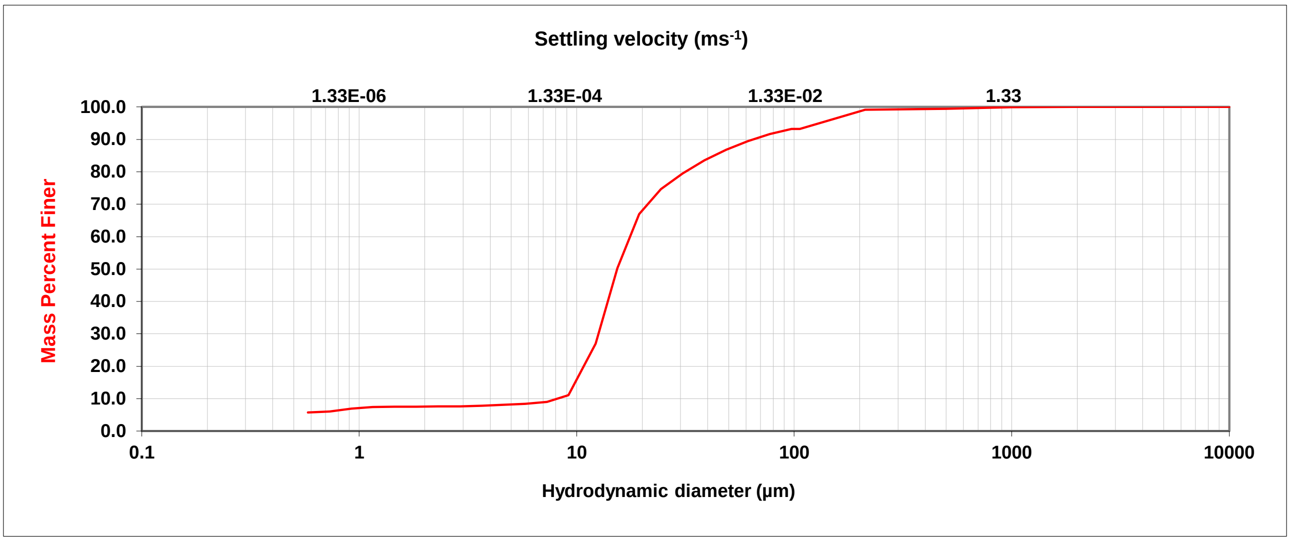
Client: Golder
Client ID: 137645044 13441826
Job No: 13_1212
Laboratory ID: 13_1212_01

Analysis: X-ray sedimentation by Sedigraph 5100
Dispersant: Water
Additives: 10 mL sodium hexametaphosphate

Analysis temp.: 35.7 ºC
Sonication: 10 min
Concentration: ~5 % w/w

Sample density: 2.473 g/cm^3 (measured)
Liquid density: 0.994 g/cm^3
Liquid viscosity: 0.724 cp

Critical diameter: 56.42 µm



Max size (µm)	Min size (µm)	In %	Mean settling velocity* (ms^{-1})	Max size (µm)	Min size (µm)	In %	Mean settling velocity* (ms^{-1})
10000.00	2000.00	0.0	1.46E+01	12.23	9.17	15.9	8.20E-05
2000.00	1000.00	0.1	1.46E+00	9.17	7.29	2.1	4.89E-05
1000.00	500.00	0.5	3.66E-01	7.29	5.79	0.6	3.09E-05
500.00	212.00	0.2	7.75E-02	5.79	4.60	0.3	1.95E-05
212.00	106.00	6.0	1.64E-02	4.60	3.65	0.3	1.23E-05
106.00	97.16	0.0	7.53E-03	3.65	2.90	0.2	7.74E-06
97.16	77.18	1.6	5.48E-03	2.90	2.30	0.0	4.88E-06
77.18	61.31	2.1	3.46E-03	2.30	1.83	0.1	3.08E-06
61.31	48.70	2.7	2.18E-03	1.83	1.45	0.0	1.94E-06
48.70	38.68	3.3	1.38E-03	1.45	1.15	0.1	1.22E-06
38.68	30.73	4.0	8.69E-04	1.15	0.92	0.6	7.73E-07
30.73	24.41	4.8	5.48E-04	0.92	0.73	0.8	4.91E-07
24.41	19.39	7.7	3.46E-04	0.73	0.58	0.3	3.10E-07
19.39	15.40	16.7	2.18E-04	0.58	0.10	5.8	4.24E-08
15.40	12.23	23.3	1.38E-04	Total:		100.0	

Note : Data from 106 µm to 10,000 µm by wet screening , from 0.3µm to 106 µm by Sedimentation.
* based on the mean of the size interval and on the the calculations and variables in the 'settling velocity worksheet

Plasticity Index Test Report

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www.golder.com
perthlab@golder.com.au

Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	26/11/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044

Test procedure: AS 1289.2.1.1,AS 1289 3.1.2, AS 1289.3.2.1, AS 1289.3.3.1 & AS 1289.3.4.1

Laboratory Reference Number	13441827
Sample Identification	Floatation and Hydrometallurgical Tailings combined with Gypsum
Sample Description	
Liquid Limit (%)	28
Plastic Limit (%)	14
Plasticity Index (%)	14
Linear Shrinkage (%)	3.0
Moisture Content (%)	ND
Sample History	Air Dried
Method of Preparation	Dry Sieved
Length of Shrinkage Mould (mm)	125
Cracking, Curling or Crumbling	No

N.D. = Not Determined **N.O. = Not Obtainable** **N.P. = Non Plastic**

Notes:

Tested as received **PLF1-007 RL0 28/11/12**

Certificate Reference: **137645044_13441827_TR-130231_PI_Rev0**

NATA Accreditation No: 1961 Perth

Accredited for compliance with ISO/IEC 17025

Hamish Campbell - Senior Laboratory Technician

Settling Tests Summary Report

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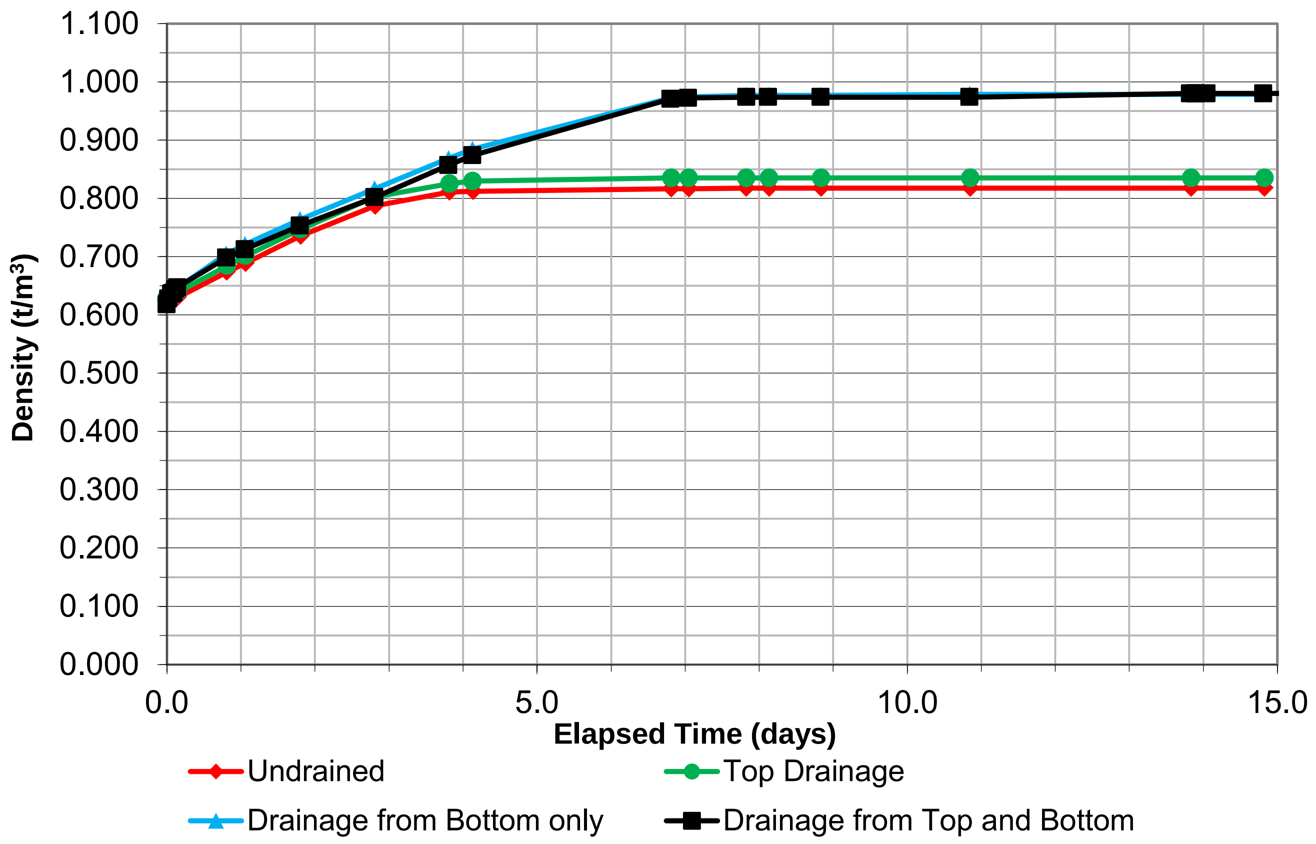
Client:	Northern Minerals Ltd (Normin)		
	PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	11/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference No.:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:	
Test Procedure	In-house Method
Tested Percent Solids (%)	45
Date Tested	11/11/2013



Notes: The tested percent solids (%) was measured at approximately 45%.

Tested as received **PLF7-007 RL0 28/02/13**

Certificate Reference:	**137645044_13441827_TR-130231_Settling_Rev0**

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Hamish Campbell - Senior Laboratory Technician

Tabulated - Undrained Settling Test Report

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Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	11/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference No.:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test Procedure	In-house Method
Tested Percent Solids (%)	44.50%
Date Tested	11/11/13

Date	Time (hr:m)	Elapsed Time (days)	Volume of Suspension (cm^3)	Total Volume (cm^3)	Dry Density (t/m^3)
11/11/13	12:15	0.000	1000	1000	0.617
11/11/13	12:19	0.003	995	1000	0.620
11/11/13	12:21	0.004	995	1000	0.620
11/11/13	12:30	0.010	995	1000	0.620
11/11/13	12:52	0.026	994	1000	0.620
11/11/13	13:05	0.035	989	1000	0.623
11/11/13	13:53	0.068	989	1000	0.623
11/11/13	14:15	0.083	988	999	0.624
11/11/13	14:39	0.100	985	999	0.626
11/11/13	15:18	0.127	980	990	0.629
11/11/13	15:52	0.151	978	990	0.630
12/11/13	07:45	0.813	915	990	0.674
12/11/13	13:50	1.066	895	990	0.689
13/11/13	07:40	1.809	838	989	0.736
14/11/13	07:51	2.817	783	989	0.787
15/11/13	07:57	3.821	760	989	0.811
15/11/13	15:35	4.139	759	989	0.812
18/11/13	07:52	6.817	755	989	0.817
18/11/13	13:32	7.053	755	989	0.817
19/11/13	08:11	7.831	754	989	0.818
19/11/13	15:34	8.138	754	989	0.818

Mass of Dry Solids (g) = 616.6

Notes:

Tested as received **PLF7-007 RL0 28/02/13**

Certificate Reference: **137645044_13441827_TR-130231_Settling_Rev0**

Hamish Campbell - Senior Laboratory Technician

Tabulated - Undrained Settling Test Report

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Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	11/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference No.:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test Procedure	In-house Method
Tested Percent Solids (%)	44.50%
Date Tested	11/11/13

Date	Time (hr:m)	Elapsed Time (days)	Volume of Suspension (cm^3)	Total Volume (cm^3)	Dry Density (t/m^3)
20/11/13	08:26	8.841	754	989	0.818
22/11/13	08:45	10.854	754	989	0.818
25/11/13	08:25	13.840	754	989	0.818
26/11/13	08:06	14.827	754	989	0.818

Mass of Dry Solids (g) = 616.6

Notes:

Tested as received **PLF7-007 RL0 28/02/13**

Certificate Reference: **137645044_13441827_TR-130231_Settling_Rev0**

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Hamish Campbell - Senior Laboratory Technician

Tabulated - Top Drained Settling Test Report

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PTH-LABORATORY@golder.com.au

Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	11/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference No.:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test Procedure	In-house Method
Tested Percent Solids (%)	45.00%
Date Tested	11/11/13

Date	Time (hr:m)	Elapsed Time (days)	Volume of Suspension (cm^3)	Fluid Siphoned Off (g)	Dry Density (t/m^3)
11/11/13	12:17	0.000	1000	-	0.626
11/11/13	12:18	0.001	995	-	0.629
11/11/13	12:22	0.003	995	-	0.629
11/11/13	12:30	0.009	995	-	0.629
11/11/13	13:54	0.067	989	-	0.633
11/11/13	14:15	0.082	988	-	0.634
11/11/13	14:40	0.099	985	-	0.636
11/11/13	15:19	0.126	980	-	0.639
11/11/13	15:53	0.150	979	-	0.640
12/11/13	07:46	0.812	915	55.93	0.684
12/11/13	13:48	1.063	893	-	0.701
13/11/13	07:41	1.808	838	62.80	0.747
14/11/13	07:52	2.816	780	63.21	0.803
15/11/13	07:58	3.820	759	-	0.825
15/11/13	15:26	4.131	755	-	0.830
18/11/13	07:51	6.815	750	-	0.835
18/11/13	13:30	7.051	750	44.41	0.835
19/11/13	08:10	7.828	750	-	0.835
19/11/13	15:35	8.138	750	-	0.835
20/11/13	08:25	8.839	750	-	0.835
22/11/13	08:46	10.853	750	-	0.835

Mass of Dry Solids (g) = 626.3

Notes:

Tested as received **PLF7-007 RL0 28/02/13**

Certificate Reference: **137645044_13441827_TR-130231_Settling_Rev0**

Hamish Campbell - Senior Laboratory Technician

Tabulated - Top Drained Settling Test Report

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Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	11/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference No.:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test Procedure	In-house Method
Tested Percent Solids (%)	45.00%
Date Tested	11/11/13

Date	Time (hr:m)	Elapsed Time (days)	Volume of Suspension (cm^3)	Fluid Siphoned Off (g)	Dry Density (t/m^3)
25/11/13	08:24	13.838	750	-	0.835
26/11/13	08:09	14.828	750	-	0.835

Mass of Dry Solids (g) = 626.3

Notes:

Tested as received — **PLF7-007 RL0 28/02/13**

Certificate Reference: **137645044_13441827_TR-130231_Settling_Rev0**

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Tabulated - Bottom Drained Settling Test Report

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Client:	Northern Minerals Ltd (Normin)		
	PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	11/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference No.:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test Procedure	In-house Method
Tested Percent Solids (%)	44.50%
Date Tested	11/11/13

Date	Time (hr:m)	Elapsed Time (days)	Volume of Suspension (cm^3)	Bottom Drainage Reading (g)	Dry Density (t/m^3)
11/11/13	12:30	0.000	1963	19.35	0.617
11/11/13	12:36	0.004	1954	-	0.620
11/11/13	12:51	0.015	1946	21.12	0.622
11/11/13	13:06	0.025	1934	-	0.626
11/11/13	13:56	0.060	1910	22.04	0.634
11/11/13	14:16	0.074	1903	-	0.636
11/11/13	14:41	0.091	1895	-	0.639
11/11/13	15:20	0.118	1881	16.51	0.644
11/11/13	15:54	0.142	1871	5.67	0.647
12/11/13	07:47	0.803	1718	78.05	0.705
12/11/13	13:53	1.058	1679	-	0.721
13/11/13	07:42	1.800	1585	62.30	0.764
14/11/13	07:53	2.808	1482	35.75	0.817
15/11/13	07:53	3.808	1394	25.06	0.869
15/11/13	15:37	4.130	1369	10.47	0.885
18/11/13	07:54	6.808	1245	66.85	0.973
18/11/13	13:34	7.044	1243	-	0.974
19/11/13	08:28	7.832	1239	20.16	0.977
19/11/13	15:31	8.126	1239	-	0.977
20/11/13	08:35	8.837	1239	19.14	0.977
22/11/13	08:47	10.845	1237	38.10	0.979

Mass of Dry Solids (g) = 1210.8

Notes:

Tested as received **PLF7-007 RL0 28/02/13**

Certificate Reference: **137645044_13441827_TR-130231_Settling_Rev0**

Hamish Campbell - Senior Laboratory Technician

Tabulated - Bottom Drained Settling Test Report

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Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	11/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference No.:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test Procedure	In-house Method
Tested Percent Solids (%)	44.50%
Date Tested	11/11/13

Date	Time (hr:m)	Elapsed Time (days)	Volume of Suspension (cm^3)	Bottom Drainage Reading (g)	Dry Density (t/m^3)
25/11/13	08:22	13.828	1237	54.51	0.979
26/11/13	08:11	14.820	1237	17.43	0.979

Mass of Dry Solids (g) = 1210.8

Notes:

Tested as received **PLF7-007 RL0 28/02/13**

Certificate Reference: **137645044_13441827_TR-130231_Settling_Rev0**

Hamish Campbell - Senior Laboratory Technician

Tabulated - Top and Bottom Drained Settling Test Report

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Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	11/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference No.:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test Procedure	In-house Method
Tested Percent Solids (%)	44.59%
Date Tested	11/11/13

Date	Time (hr:min)	Elapsed Time (days)	Volume of Suspension (cm^3)	Fluid Siphoned Off (g)	Bottom Drainage Reading (g)	Dry Density (t/m^3)
11/11/13	12:35	0.000	1973	-	-	0.618
11/11/13	13:06	0.022	1944	-	26.5	0.628
11/11/13	13:57	0.057	1918	-	16.6	0.636
11/11/13	14:17	0.071	1914	-	-	0.637
11/11/13	14:42	0.088	1912	-	-	0.638
11/11/13	15:21	0.115	1893	-	16.0	0.645
11/11/13	15:55	0.139	1885	-	5.7	0.647
12/11/13	07:49	0.801	1748	40.8	80.1	0.698
12/11/13	13:51	1.053	1712	-	-	0.713
13/11/13	07:44	1.798	1620	61.4	-	0.753
14/11/13	07:54	2.805	1522	-	44.9	0.802
15/11/13	07:54	3.805	1424	110.0	34.2	0.857
15/11/13	15:36	4.126	1396	-	9.3	0.874
18/11/13	07:53	6.804	1257	-	60.9	0.971
18/11/13	13:33	7.040	1255	-	-	0.972
19/11/13	08:26	7.827	1253	-	17.5	0.974
19/11/13	15:32	8.123	1253	-	-	0.974
20/11/13	08:30	8.830	1253	-	16.5	0.974
22/11/13	08:49	10.843	1253	-	34.3	0.974
25/11/13	08:19	13.822	1245	-	48.7	0.980
25/11/13	10:00	13.892	1245	-	-	0.980

Mass of Dry Solids (g) = 1220.1

Notes:

Tested as received **PLF7-007 RL0 28/02/13**

Certificate Reference: **137645044_13441827_TR-130231_Settling_Rev0**

Hamish Campbell - Senior Laboratory Technician

Tabulated - Top and Bottom Drained Settling Test Report

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PTH-LABORATORY@golder.com.au

Client: Northern Minerals Ltd (Normin)
PO Box 669, West Perth WA 6872

Project: Browns Range Project **Date:** 11/12/13

Location: Tanami Desert of WA and the Northern Territory **Project No.:** 137645044

Lab Reference No.: 13441827 **Sample Identification:** Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test Procedure	In-house Method
Tested Percent Solids (%)	44.59%
Date Tested	11/11/13

Date	Time (hr:min)	Elapsed Time (days)	Volume of Suspension (cm^3)	Fluid Siphoned Off (g)	Bottom Drainage Reading (g)	Dry Density (t/m^3)
25/11/13	10:02	13.894	1245	-	-	0.980
25/11/13	13:40	14.045	1245	-	-	0.980
26/11/13	08:03	14.811	1245	-	-	0.980
27/11/13	07:53	15.804	1245	-	-	0.980
29/11/13	08:00	17.809	1245	-	-	0.980
2/12/13	07:45	20.799	1245	-	-	0.980
3/12/13	08:15	21.819	1245	-	-	0.980
4/12/13	07:40	22.795	1245	-	-	0.980
5/12/13	15:27	24.119	1245	-	-	0.980

Mass of Dry Solids (g) = 1220.1

Notes:

Tested as received **PLF7-007 RL0 28/02/13**

Certificate Reference: **137645044_13441827_TR-130231_Settling_Rev0**

Hamish Campbell - Senior Laboratory Technician

Moisture Density Test - Air Drying

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www.golder.com
perthlab@golder.com.au

Client: Northern Minerals Ltd (Normin)
PO Box 669, West Perth WA 6872

Project: Browns Range Project | **Date:** 20/12/13

Location: Tanami Desert of WA and the Northern Territory | **Project No.:** 137645044

Test procedure: **AS1289.2.1.1, Density Determination by Direct Measurement & Calculated as per AS1289.5.2.1**

Lab Reference Number: 13441827 | **Sample Identification:** Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Tested Percent Solids (%) : 45

Date Sampled	Moisture Content (%)	Dry Density (t/m^3)
18/11/2013	50.8	1.141
21/11/2013	43.3	1.248
25/11/2013	36.0	1.362
28/11/2013	27.1	1.389
2/12/2013	17.8	1.429
6/12/2013	4.9	1.476

Tested as received

Notes: A sample of the slurry was poured into a container & allowed to drain top & bottom.
Tube samples for moisture & density determinations were taken at various intervals as the material continued to dry back.

Tested as received **PLF7-002 RL0 5/02/13**

Certificate Reference: **137645044_13441827_TR-130231_Moisture Density_Rev0**

NATA

Hamish Campbell - Senior Laboratory Technician

Tabulated - Air Drying (Winter Cycle) Test Report

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Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	10/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference Number:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

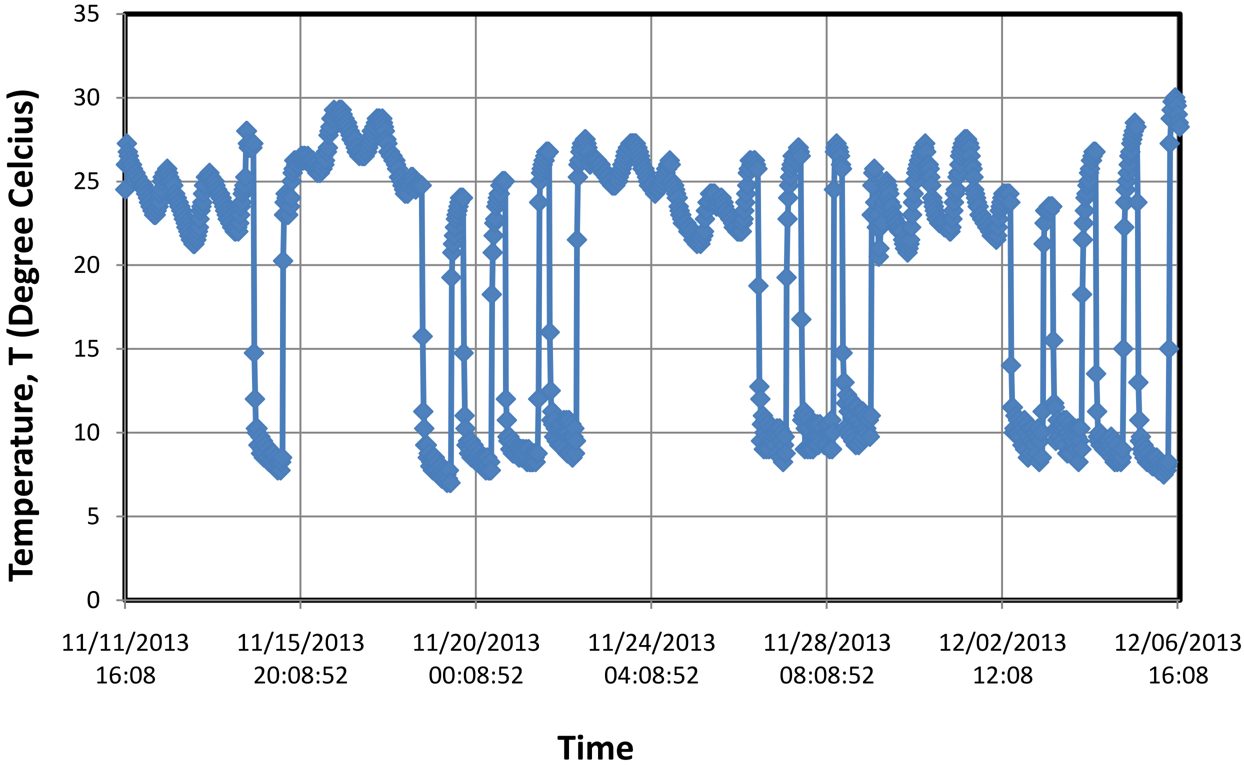
Laboratory Specimen Description:

Test procedure: Internal

Required Winter Cycle: **NOTE: * Temperatures recorded on the bench during the day.**
9-22°C (During the day, on the bench in the lab. During the night in the fridge).

Test Performed with material at 45% Percent Solids

Date Tested: 11/11/2013



Notes:

Tested as received **PLF7-006 RL0 21/01/13**

Certificate Reference:	**137645044_13441827_TR-130231_Winter Cycle_Rev0**

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Hamish Campbell - Senior Laboratory Technician

Tabulated - Air Drying (Winter Cycle) Test Report

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Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	10/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference Number:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test procedure: Internal

Initial Container & Wet Sample	**g**	1867.7
Initial Container & Wet Sample After Decant	**g**	1737.3
Final Container & Dry Sample	**g**	1272.2
Container	**g**	731.7
Final Dry Sample Mass	**g**	540.5

Required Winter Cycle: **NOTE: * Temperatures recorded on the bench during the day.**
9-22°C (During the day, on the bench in the lab. During the night in the fridge).

Date Tested: 11/11/2013

Date:	Time hr:min	Elapsed Time (days)	Sample & Container (g)	Wet Mass (g)	Moisture content (%)
11/11/13	15:56	0.000	1867.7	1136.0	110.2
12/11/13	9:27	0.730	1737.3	1005.7	86.1
13/11/13	7:36	1.653	1714.6	983.0	81.9
14/11/13	9:04	2.714	1689.4	957.7	77.2
14/11/13	16:17	3.015	1681.0	949.3	75.6
15/11/13	8:52	3.706	1664.3	932.7	72.5
15/11/13	16:00	4.003	1647.0	915.3	69.3
18/11/13	10:23	6.769	1636.5	904.9	67.4
19/11/13	8:37	7.695	1621.8	890.1	64.7
19/11/13	15:52	7.997	1610.9	879.3	62.7
20/11/13	7:50	8.663	1596.8	865.1	60.1
20/11/13	15:38	8.988	1584.3	852.6	57.7
21/11/13	10:45	9.784	1567.9	836.2	54.7
21/11/13	16:45	10.034	1558.8	827.1	53.0
22/11/13	8:24	10.686	1544.9	813.2	50.4
22/11/13	16:05	11.006	1537.2	805.5	49.0

Notes:

Tested as received **PLF7-006 RL0 21/01/13**

Certificate Reference: **137645044_13441827_TR-130231_Winter Cycle_Rev0**

Hamish Campbell - Senior Laboratory Technician

Tabulated - Air Drying (Winter Cycle) Test Report

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Client: Northern Minerals Ltd (Normin)
PO Box 669, West Perth WA 6872

Project: Browns Range Project | **Date:** 10/12/13

Location: Tanami Desert of WA and the Northern Territory | **Project No.:** 137645044

Lab Reference Number: 13441827 | **Sample Identification:** Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test procedure: Internal

Required Winter Cycle: **NOTE: * Temperatures recorded on the bench during the day.**
9-22°C (During the day, on the bench in the lab. During the night in the fridge).

Date Tested: 11/11/2013

Date:	Time hr:min	Elapsed Time (days)	Sample & Container (g)	Wet Mass (g)	Moisture content (%)
25/11/13	8:36	13.694	1536.8	805.2	49.0
26/11/13	7:52	14.664	1493.3	761.7	40.9
26/11/13	16:02	15.004	1476.4	744.7	37.8
27/11/13	7:54	15.665	1463.0	731.4	35.3
27/11/13	16:42	16.032	1444.7	713.0	31.9
28/11/13	11:50	16.829	1430.0	698.4	29.2
28/11/13	15:52	16.997	1421.2	689.6	27.6
29/11/13	8:05	17.673	1408.1	676.4	25.1
29/11/13	15:55	17.999	1398.0	666.3	23.3
2/12/13	7:55	20.666	1397.6	666.0	23.2
2/12/13	15:50	20.996	1374.1	642.5	18.9
3/12/13	10:05	21.756	1361.7	630.0	16.5
3/12/13	15:58	22.001	1344.6	613.0	13.4
4/12/13	8:25	22.687	1333.9	602.2	11.4
4/12/13	16:12	23.011	1321.6	589.9	9.1
5/12/13	8:04	23.672	1311.7	580.0	7.3
5/12/13	16:06	24.007	1298.1	566.4	4.8
6/12/13	10:05	24.756	1291.1	559.4	3.5
6/12/13	16:45	25.034	1283.5	551.8	2.1

Notes:

Tested as received **PLF7-006 RL0 21/01/13**

Certificate Reference: **137645044_13441827_TR-130231_Winter Cycle_Rev0**

Hamish Campbell - Senior Laboratory Technician

Tabulated - Air Drying (Summer Cycle) Test Report

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Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	10/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference Number:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

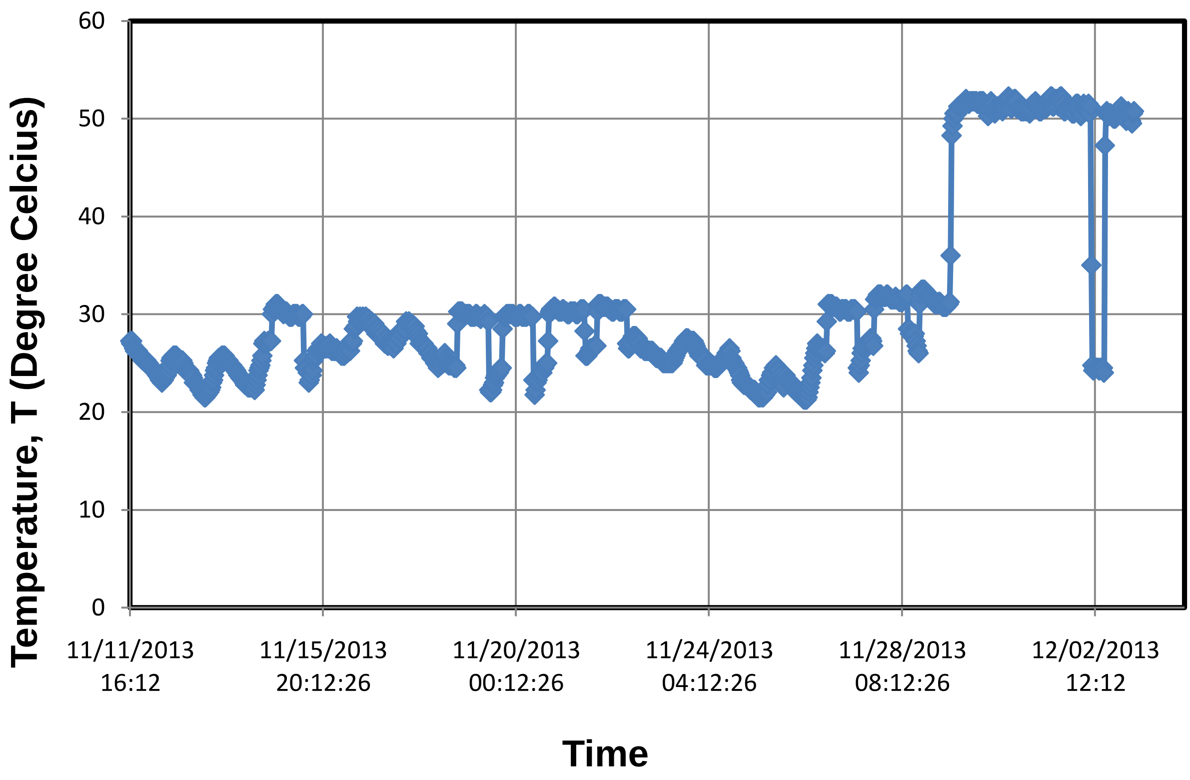
Laboratory Specimen Description:

Test procedure: Internal

Required Summer Cycle: **NOTE: * Temperatures recorded on the bench during the day.**
25-38°c (During the day, on the bench in the lab. During the night, in the oven)

Test Performed with material at 45% Percent Solids

Date Tested: 11/11/2013



Notes:

Tested as received **PLF7-005 RL0 21/01/13**

Certificate Reference: **137645044_13441827_TR-130231_Summer Cycle_Rev0**

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Tabulated - Air Drying (Summer Cycle) Test Report

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Client:	Northern Minerals Ltd (Normin) PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	10/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference Number:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test procedure: Internal

Initial Container & Wet Sample	g	1833.4
Initial Container & Wet Sample After Decant	g	1702.4
Final Container & Dry Sample	g	1256.8
Container	g	729.8
Final Dry Sample Mass	g	527.0

Required Summer Cycle: **NOTE: * Temperatures recorded on the bench during the day.**
25-38°c (During the day, on the bench in the lab. During the night, in the oven)

Date Tested: 11/11/2013

Date:	Time hr:min	Elapsed Time (days)	Sample & Container (g)	Wet Mass (g)	Moisture content (%)
11/11/13	15:53	0.000	1833.4	1103.6	109.4
12/11/13	9:25	0.731	1702.4	972.6	84.6
13/11/13	7:37	1.656	1678.6	948.8	80.1
14/11/13	9:02	2.715	1653.0	923.2	75.2
14/11/13	16:15	3.015	1645.5	915.7	73.8
15/11/13	9:50	3.748	1603.0	873.2	65.7
15/11/13	16:01	4.006	1581.1	851.3	61.6
18/11/13	16:24	7.022	1571.1	841.3	59.6
19/11/13	8:37	7.697	1519.2	789.4	49.8
19/11/13	15:50	7.998	1504.5	774.7	47.0
20/11/13	7:53	8.667	1448.3	718.5	36.3
20/11/13	15:36	8.988	1432.3	702.5	33.3
21/11/13	10:44	9.785	1364.1	634.3	20.4
21/11/13	16:46	10.037	1351.9	622.1	18.1
22/11/13	8:22	10.687	1308.3	578.5	9.8
22/11/13	16:02	11.006	1300.0	570.2	8.2

Notes:

Tested as received **PLF7-005 RL0 21/01/13**

Certificate Reference: **137645044_13441827_TR-130231_Summer Cycle_Rev0**

Hamish Campbell - Senior Laboratory Technician

Tabulated - Air Drying (Summer Cycle) Test Report

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Client:	Northern Minerals Ltd (Normin)		
	PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	10/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044
Lab Reference Number:	13441827	**Sample Identification:**	Floatation and Hydrometallurgical Tailings combined with Gypsum

Laboratory Specimen Description:

Test procedure: Internal

Required Summer Cycle: **NOTE: * Temperatures recorded on the bench during the day.**
25-38°c (During the day, on the bench in the lab. During the night, in the oven)

Date Tested: 11/11/2013

Date:	Time hr:min	Elapsed Time (days)	Sample & Container (g)	Wet Mass (g)	Moisture content (%)
25/11/13	8:35	13.696	1299.7	569.9	8.2
26/11/13	7:54	14.667	1270.8	541.0	2.7
26/11/13	15:59	15.004	1265.0	535.2	1.6
27/11/13	7:52	15.666	1258.6	528.8	0.3
27/11/13	16:40	16.033	1258.8	529.0	0.4
28/11/13	9:45	16.744	1258.3	528.5	0.3
28/11/13	15:49	16.997	1258.8	529.0	0.4
29/11/13	8:02	17.673	1258.2	528.4	0.3
2/12/13	7:57	20.669	1256.8	527.0	0.0
3/12/13	7:59	21.671	1256.8	527.0	0.0

Notes:

Tested as received **PLF7-005 RL0 21/01/13**

Certificate Reference: **137645044_13441827_TR-130231_Summer Cycle_Rev0**

Hamish Campbell - Senior Laboratory Technician

Slurry Consolidometer Test Report

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Client: Northern Minerals Ltd (Normin)
PO Box 669, West Perth WA 6872

Project: Browns Range Project **Date:** 10/12/13

Location: Tanami Desert of WA and the Northern Territory **Project No.:** 137645044

Test procedure: In-house

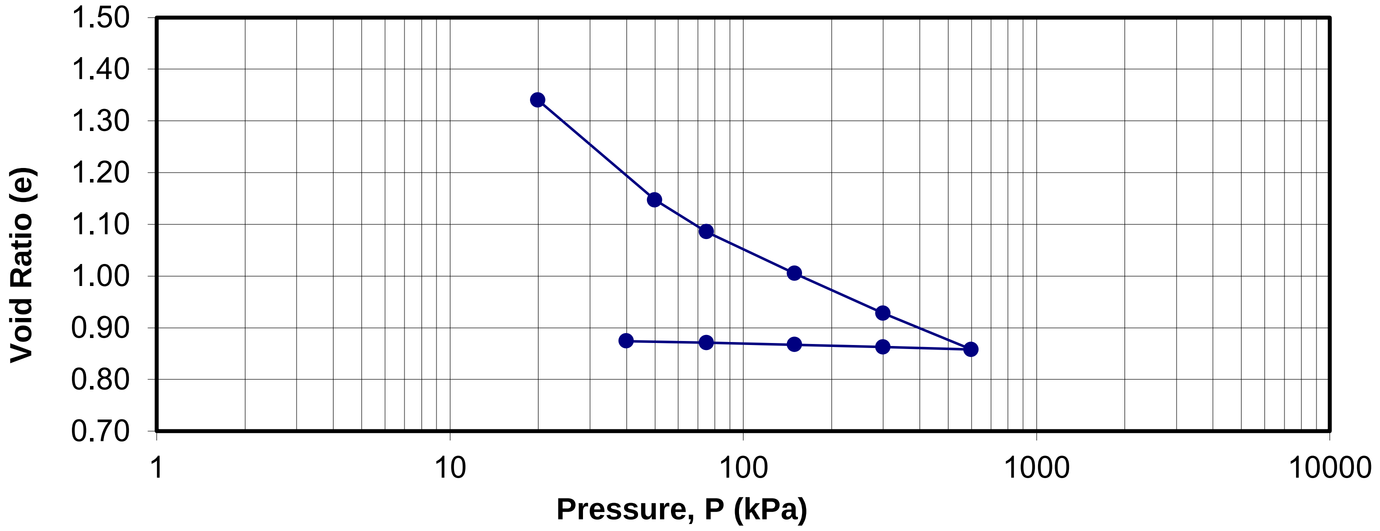
Lab Reference Number : 13441827 **Sample Identification :** Bulk tailings sample.

Laboratory Specimen Description: Floatation and Hydrometallurgical Tailings combined with Gypsum

Specimen Type: Slurry Sample

Test Conditions: Top drainage of specimen while undergoing compression

Sample Diameter (mm): 71



Pressure (kPa)	Settlement (%)	Void Ratio (e)	Permeability (m/sec)	Confining Modulus, M (kPa)	m_v (m^2/MN)	SG (Measured) 2.67	
Initial	0	2.40	-	-	-		
20	31.1	1.34	3.4E-08	35	33.52		
50	36.8	1.15	1.9E-08	364	2.86	Initial Dry Density (t/m^3)	0.786
75	38.6	1.09	1.6E-08	873	1.16		
150	41.0	1.00	1.0E-08	1938	0.53		
300	43.3	0.93	8.8E-09	3912	0.26	Final MC (%)	32.7%
600	45.3	0.86	6.5E-09	8257	0.12		
300	45.2	0.86	-	118636	0.01	Final Dry Density (t/m^3)	1.425
150	45.0	0.87	-	59468	0.02		
75	44.9	0.87	-	36433	0.03		
40	44.8	0.87	-	21905	0.05		

Notes: The sample of tailings was created combining the floatation and hydrometallurgical tailings with commercial gypsum at the following percentages: 95.02% Floatation Tailings, 4.31% Hydrometallurgical Tailings, 0.67% Commercial Gypsum.
The sample was then prepared to 45% solids prior to testing.

Sample provided by Client. **PLF7-008 RL0 28/03/13**

Certificate Reference: **137645044_13441827_TR-130211_Slurry Consol_Rev0**

Stephen Abbey - Senior Laboratory Technician

Vane Yield Stress Test Summary Report

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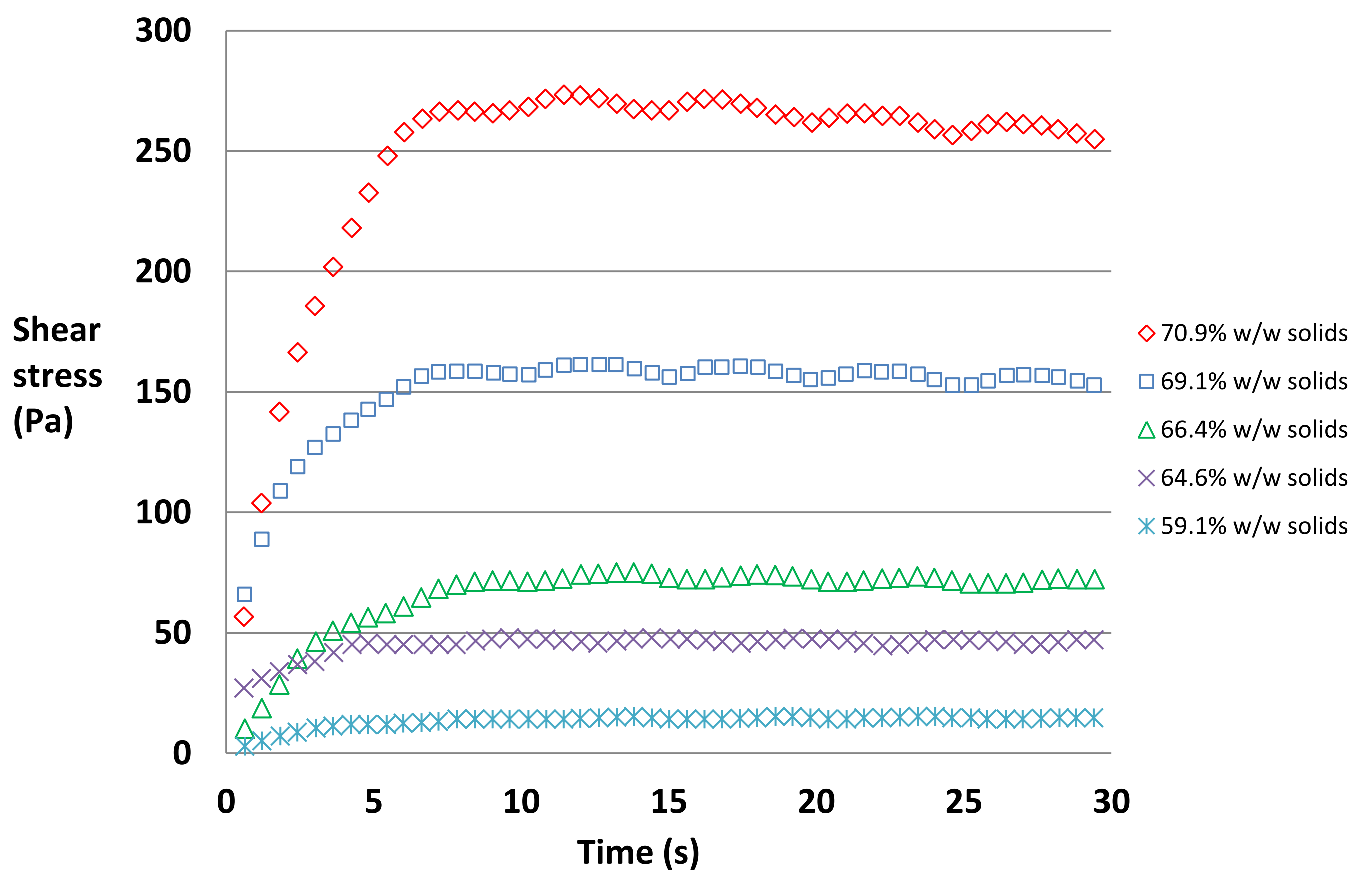
Client:	Northern Minerals Ltd (Normin)		
	PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	20/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044

Lab Reference Number:	13441827
Sample Identification:	Floatation and Hydrometallurgical Tailings combined with Gypsum
Sample Description:	



Flocculated:	No	**Shear rate:**	0.104 (1/s)
Dosage:	-	**Yield stress value (Pa):**	-

Notes:

Tested as received **PLF1-022 RL0 21/02/13**

Certificate Reference:	**137645044_13441827_TR-130231_Vane Yield Stress_Rev0**

Raymond Guang - Process Engineer

Vane Yield Stress Test Summary Report

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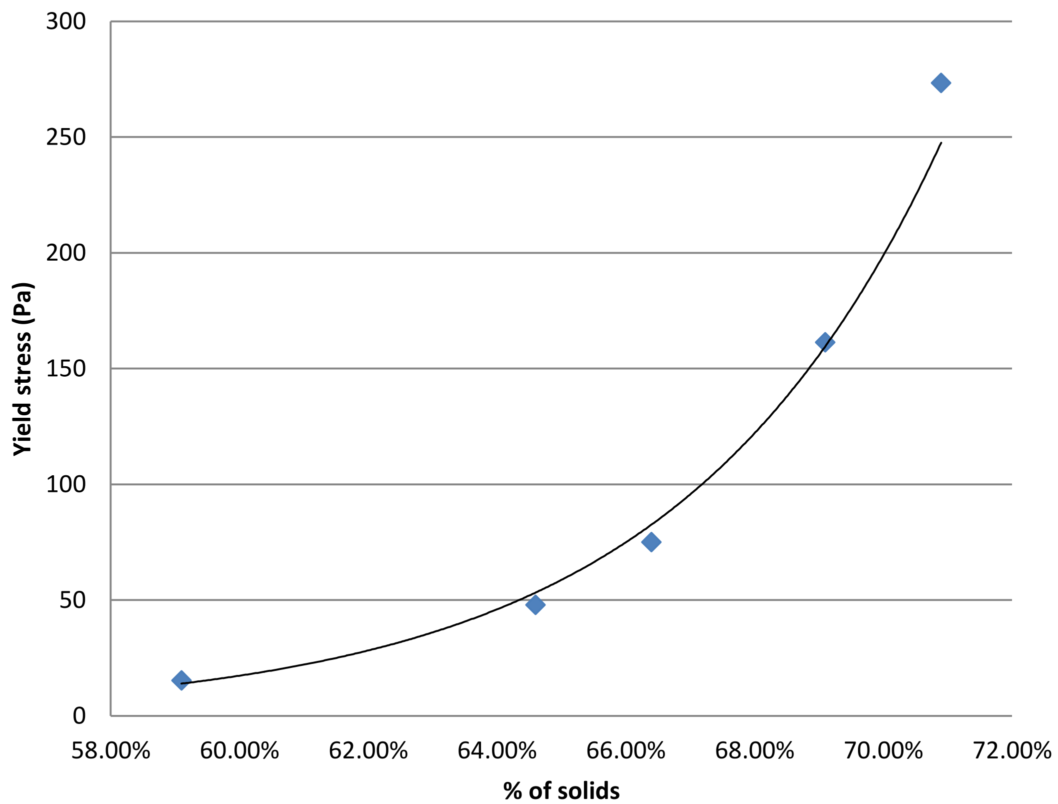
Client:	Northern Minerals Ltd (Normin)		
	PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	20/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044

Lab Reference Number:	13441827
Sample Identification:	Floatation and Hydrometallurgical Tailings combined with Gypsum
Sample Description:	



Flocculated:	No	**Shear rate:**	0.104 (1/s)
Dosage:	-	**Yield stress value (Pa):**	-

Notes:

Tested as received **PLF1-022 RL0 21/02/13**

Certificate Reference:	**137645044_13441827_TR-130231_Vane Yield Stress_Rev0**

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Raymond Guang - Process Engineer

Viscosity Summary Report

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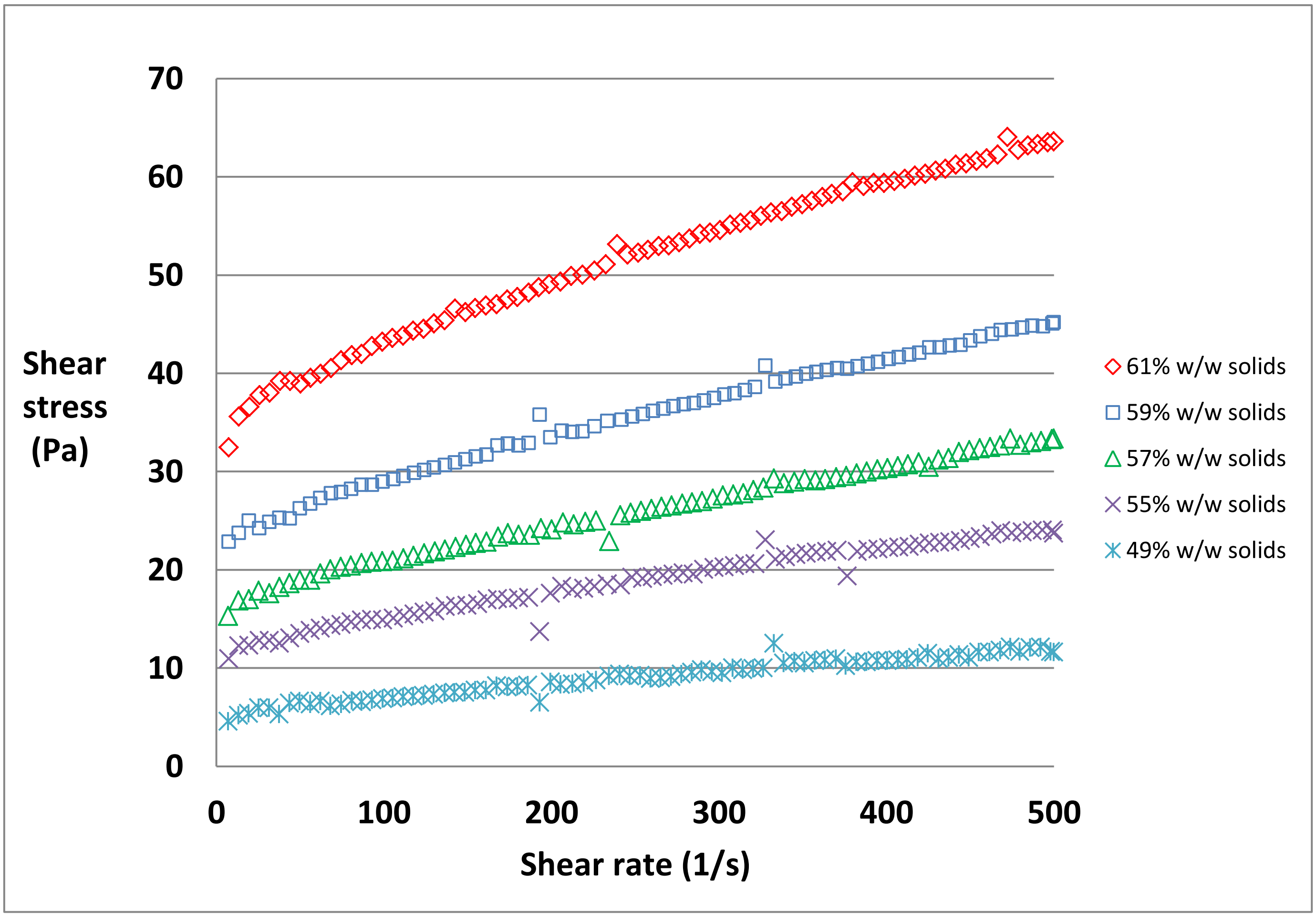
Client:	Northern Minerals Ltd (Normin)		
	PO Box 669, West Perth WA 6872		
Project:	Browns Range Project	**Date:**	20/12/13
Location:	Tanami Desert of WA and the Northern Territory	**Project No.:**	137645044

Lab Reference Number:	13441827
Sample Identification:	Floatation and Hydrometallurgical Tailings combined with Gypsum
Sample Description:	



Flocculated:	No	**Shear rate:**	7 - 500 (1/s)
Dosage:	-	**Yield stress value (Pa):**	-

Notes:

Tested as received **PLF1-020 RL0 19/02/13**

Certificate Reference:	**137645044_13441827_TR-130231_Viscosity_Rev0**

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Hamish Campbell - Senior Laboratory Technician

APPENDIX B

FLSmidth Tailings Thickening Report

REPORT OF INVESTIGATION

INTO THE

THICKENING OF

BROWNS RANGE
RARE EARTH MINERAL
TAILINGS

FOR

NORTHERN MINERALS

by

Dannie Othman & Kim Vance
FLSmidth Pty Ltd
November 2013

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1.0 SUMMARY

FLSmidth was commissioned by Golder Associates on behalf of Northern Minerals to carry out bench scale thickening testwork on one (1) sample of Browns Range Rare Earth Mineral Tailings.

The objective of the testwork was to size the options of High Rate and Deep cone Paste thickeners capable thickening 70 t/h of Browns Range Rare Earth Mineral Tailings to optimum underflow solids.

The testwork indicated the feed rate of up to 70 t/h of Browns Range Rare Earth Mineral Tailing solids can be thickened to underflow solids of 57% – 59% w/w in a 12m ϕ High Rate Thickener or to underflow solids of 65% – 68% w/w in a 12m ϕ Deep Cone Thickener.

The Table below summarises the expected performance of the 12m ϕ High Rate Thickener and Deep Cone Thickener when processing 70 t/h of Browns Range Rare Earth Mineral Tailings.

Expected Performance of 12 m ϕ High Rate & 12 m ϕ Deep Cone Thickeners Browns Range Rare Earth Mineral Tailings.

Parameter		Expected Performance 12m ϕ High Rate Thickener	Expected Performance 12m ϕ Deep Cone Thickener
Thickener Feed Rate	**t/h**	70	70
Feed Solids	**% w/w**	50	50
Feed Flow Rate	**m^3/h**	990	990
Feedwell Solids	**% w/w**	5	5
Flocculant Addition Rate	**g/t**	20	20
Rise Rate	**m/h**	2.5	2.5
Overflow Solids	**mg/l**	<200	<200
Underflow Solids	**% w/w**	57 - 59	65 - 68
Underflow Yield Stress	**Pa**	22 - 35	116 – 228
Flux Rate	**t/m^2h**	0.62	0.62
Total Thickener Height	**m**	6.3	9.7
Thickener Diameter	**m**	12 m ϕ	12 m ϕ
Number of Thickeners		1	1

2.0 INTRODUCTION

FLSmidth was commissioned by Golder Associates on behalf of Northern Minerals to carry out bench scale thickening testwork on one (1) sample of Browns Range Rare Earth Mineral Tailings.

The objective of the testwork was to size the options of High Rate and Deep cone Paste thickeners capable thickening 70 t/h of Browns Range Rare Earth Mineral Tailings to optimum underflow solids.

The testwork was conducted at Golder Associates laboratory located in Osborne Park, Perth, Western Australia.

This report details the results of the bench scale thickening testwork conducted on the sample of Browns Range Rare Earth Mineral Tailings and discusses the size of High Rate and Deep Cone Paste Thickeners required to process the target solids feed rate to optimal underflow solids levels.

3.0 PROCEDURES

3.1 Thickener Feed

One (1) sample of Browns Range Rare Earth Mineral Tailings slurry was supplied by Golder Associates.

Settling flux tests were conducted to determine the optimum feedwell solids concentration to achieve maximum settling performance.

3.2 4 Litre Static Cylinder Settling Tests

A series of static 4 litre cylinders settling tests were conducted on the Tailings sample.

The test cylinders were fitted with slowly rotating pickets to simulate the action of the rake in the full scale thickener.

3.3 Continuous Fill Deep Tube Settling Tests

Continuous fill thickening tests were conducted on the Tailings sample. The continuous fill settling tests involved pumping slurry at the optimum settling flux concentration and flocculant at the settling flux addition rate into a 4 litre test cylinder containing a feedwell to mix and flocculate the slurry. The flocculated slurry then settled towards the bottom of the cylinder and the clear overflow exited from the top of the cylinder.

The 4 litre cylinder was fitted with a slowly rotating rake to assist with the dewatering of the slurry the same way as the rake mechanism assists dewatering in the full scale thickener.

The objectives of the continuous fill tests were to: -

- Confirm the optimum settling flux solids concentration determined in the static settling flux tests.
- Confirm the flocculant addition rate determined in the settling flux tests.
- Establish the relationship between rise rates, flocculant addition rate and overflow solids levels.
- Determine the bed residence time required for the full scale thickeners to achieve maximum or target underflow density levels.

Typical fill time for the continuous fill test is 25 to 40 minutes depending on the solids flux rate. The feed rate and flocculant addition rate were initially set to approximately 50% of the predicted solids flux rate and at 100% of the expected flocculant addition rate on a g/t basis. After initial observations of flocc structure, settling velocity and overflow clarity the feed rate was increased to the expected maximum with a corresponding increase in flocculant addition rate to maintain the correct addition rate on a g/t basis. If any degradation in flocc structure or significant decrease in overflow clarity was observed the flocculant addition rate was increased to bring these two parameters back into acceptable limits.

The continuous fill test continued until a solids bed depth of 0.5 – 0.8m was achieved. Once the target bed level was achieved the feed to the cylinder was stopped and readings of the bed height versus time taken until the there was no further decrease in interface height. Typically there is no further decrease in bed height after 6 – 8 hours.

Once there was no further decrease in interface height the time was noted, the clear liquor was decanted off, and the compacted slurry removed from the cylinder, dried and weighed in order to measure the solids concentration in the cylinder and check the volume of feed slurry added during the test.

3.4 Filter Leaf Test

A vacuum filter leaf test in which the filter cake remains fully saturated with filtrate was conducted on the tailings. The filter leaf test is an important characterisation test for solids to be thickened in thickeners. The saturated cake approximates the limit to which the solid particles can be concentrated and thus provides valuable information related to the target underflow solids for thickeners.

3.5 Flocculant

The flocculant used for the bench-scale thickening tests was BASF Magnafloc 5250. Magnafloc 5250 was selected for the testwork after a number of other flocculants were evaluated.

3.6 Underflow Rheology

The yield stress for the tailings sample thickened to a range of solids densities were measured using a Haake VT550 Viscometer equipped with a vane sensor.

3.7 Particle Size Distribution

The particle size distribution of the tailings solids used in the thickener simulations was provided by Golder Associates.

4.0 RESULTS

4.1. Solids Characterisation

4.1.1 Particle Size Distribution

Table 4.1.1 – Particle Size Distribution – Browns Range Rare Earth Mineral Tailings

Size (µm)	% Passing
500	99.9
150	92.5
75	82.0
63	78.0
38	62.0
P80	***69 µm***

4.1.2 Specific Gravities

SG of Solids 2.7

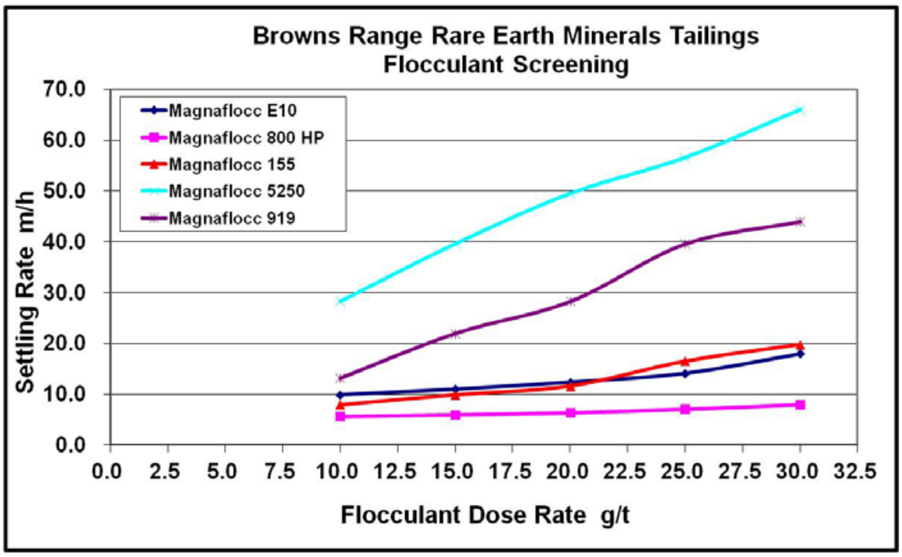
SG of Water 1.00

4.2 Flocculant Screening

The flocculants evaluated during this testwork were BASF Magnafloc 10, 155, 5250, 919 and 800HP. The results of the flocculant screening tests for Browns Range Rare Earth Mineral Tailings sample are shown in Graph 4.2.

The flocculant selected for the thickener simulation testwork was Magnafloc 5250 as it was the best performing flocculant in terms of free settling rate and overflow clarity.

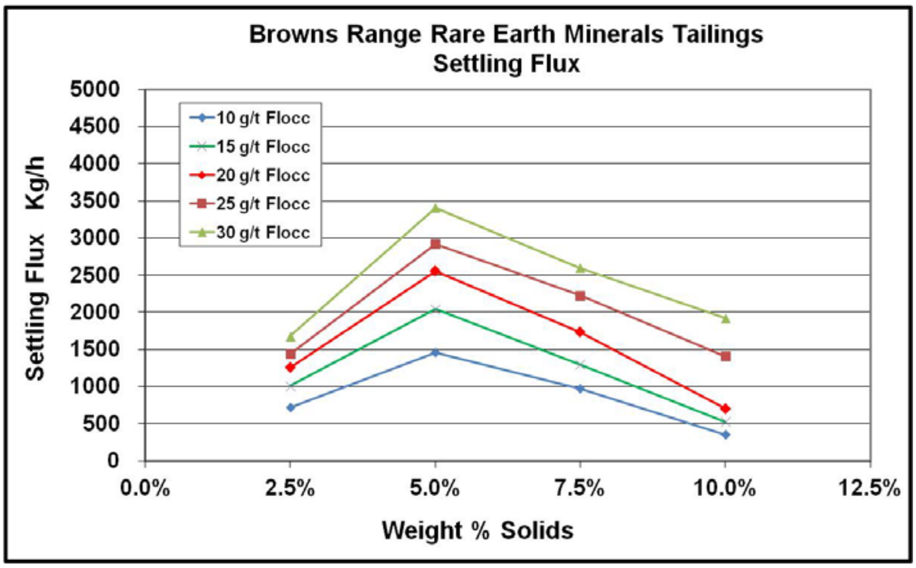
Graph 4.2 – Flocculant Screening – Browns Range Rare Earth Mineral Tailings.



4.3 Effect of Feed Dilution

The settling flux curves shown in Graph 4.3 indicate that the sample of Browns Range Rare Earth Mineral Tailings sample exhibits optimum settling performance at feedwell solids concentrations of 5.0 % w/w. Above the optimum feed solids concentration, there is deterioration in settling performance as the settling rate is adversely affected by hindered settling.

Graph 4.3 Settling Flux – Browns Range Rare Earth Mineral Tailings.



4.4 4 Litre Static Cylinder Settling Tests

The results of the bench scale 4 Litre Static Cylinder thickening simulations on the tailings sample are summarised in Table 4.4.

The data was obtained from the settling curves that are provided along with the summary sheets in Appendix 1.

Table 4.4 – Browns Range Rare Earth Mineral Tailings
4 Litre Static Cylinder Settling Test Results.

Test Parameter		Test 1
Test Size	**litre**	4.0
Feed Solids	**% w/w**	5.0
Flocculant Type - BASF		Magnafloc 5250
Flocculant Addition	**g/t**	20
Mode of Flocculant Addition		Multistage
Free Settling Rate	**m/h**	33
Overflow Solids	**mg/l**	<200
Ultimate Solids	**% w/w**	56.1

Table 4.4 indicates that the sample of Browns Range Rare Earth Mineral Tailings sample exhibits the following settling and thickening characteristics:

- Settling rate of 33 m/h when the solids are flocculated at 5.0% w/w with 20 g/t of BASF Magnafloc 5250 flocculant.
- Overflow solids of <200 mg/l.
- Ultimate underflow solids values of 56.1% w/w.

4.5 Vacuum Filter Leaf Test

The results of the vacuum filter leaf tests on the Browns Range Rare Earth Mineral Tailings sample in which the filter cake remained saturated with filtrate recorded a solids value of 76.9 % w/w.

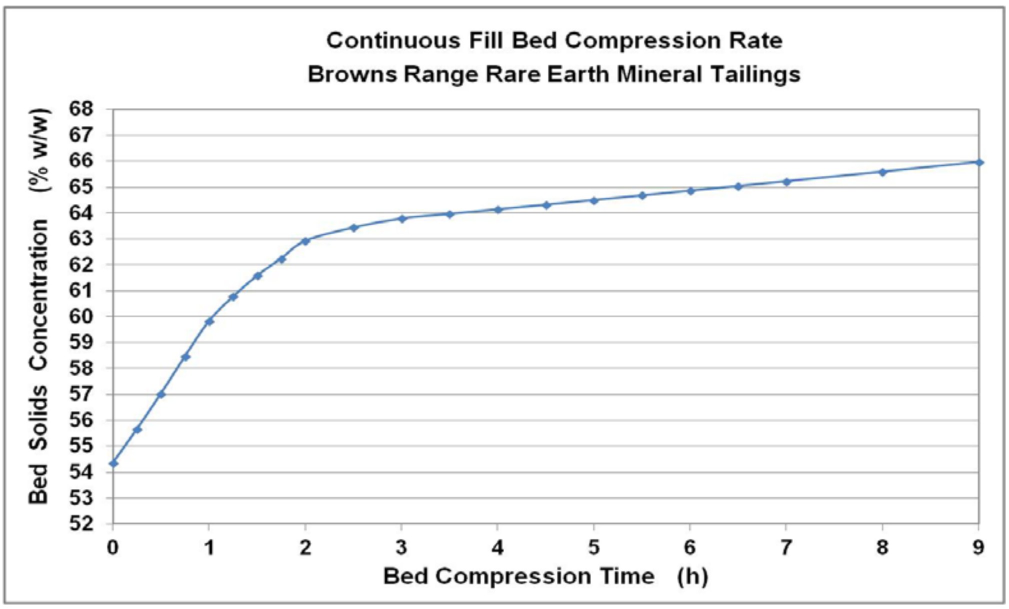
4.6 Continuous Fill Deep Tube Compaction Tests

The results of the continuous fill deep tube compaction test conducted on the sample of Browns Range Rare Earth Mineral Tailings are summarised in Table 4.6 and the raked compression is illustrated in Graph 4.6 overleaf.

Table 4.6 – Browns Range Rare Earth Mineral Tailings
Continuous Fill Deep Tube Compaction Test Parameters and Results.

Test Parameter		Results
Feed Solids	% w/w	5.0
Flocculant Type		Magnafloc 5250
Flocculant Addition Rate	g/t	20
Mode of Flocculant Addition		Multistage
Flux Rate	t/m^2h	0.62
Unit Area	m^2/tpd	0.07
Rise Rate	m/h	2.5
Overflow Solids	mg/l	<200
Bed Solids – 0.75 h Residence Time	% w/w	58.5
Bed Solids – 8.0 h Residence Time	% w/w	65.6
Final Bed Solids	% w/w	66.0

Graph 4.6 – Browns Range Rare Earth Mineral Tailings
Continuous Fill Bed Compression Rate.



4.7 Underflow Rheology

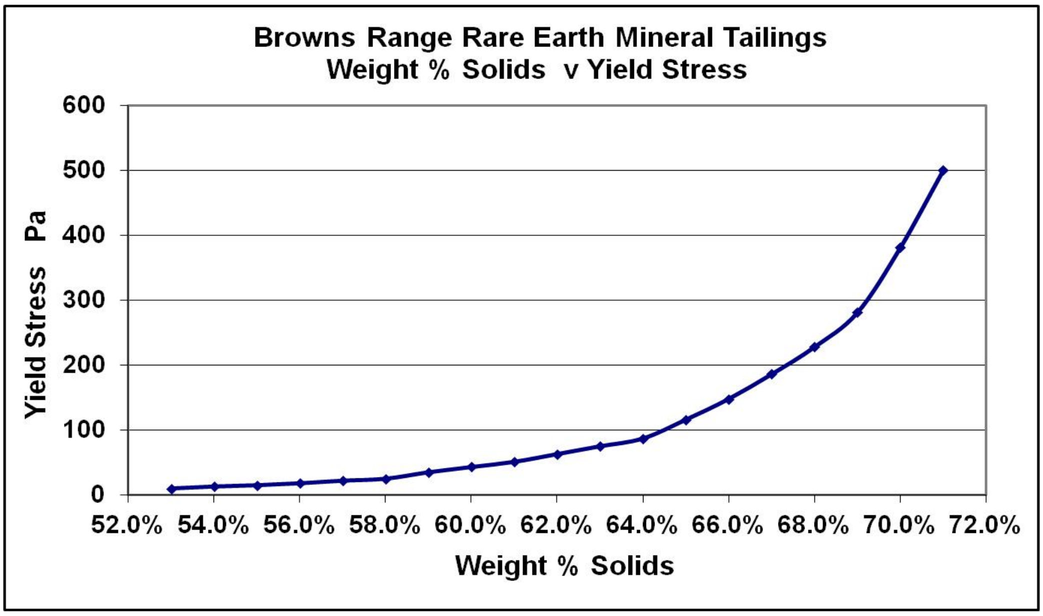
Underflow yield stress data was obtained on the sample of Browns Range Rare Earth Mineral Tailings sample over a range of solids densities using a Haake viscometer VT-550 and a vane sensor. The yield stress results are presented in Table 4.7 and the yield stress curves in Graph 4.7.

Table 4.7 – Browns Range Rare Earth Mineral Tailings Yield Stress Results.

Underflow Solids % w/w	Yield Stress Pa	Underflow Solids % w/w	Yield Stress Pa
56 %	18	64 %	87
57 %	22	65 %	116
58 %	25	66 %	148
59 %	35	67 %	186
60 %	43	68 %	228
61 %	51	69 %	281
62 %	63	70 %	381
63 %	75	71%	500

Typically High Rate thickeners produce underflow solids with a yield stress of 20 – 40Pa and typically Deep Cone thickeners produce underflow solids with a yield stress of 100 – 300Pa

Graph 4.7 – Browns Range Rare Earth Mineral Tailings Yield Stress Curve.



5.0 DISCUSSION

5.1 Feedwell Solids

As detailed in section 4.3 the optimum solids settling flux for the Browns Range Rare Earth Mineral Tailings sample was found to be 5.0 % w/w. As the feed stream to the Thickener is expected to have feed solids concentration of 20.0 % w/w, the thickeners will require a feed dilution system.

An EIMCO Open Channel E-DUC® Feed System is capable of diluting the feed stream to the desired level. The EIMCO E-DUC® Feed System uses clarified liquor from within the thickener to dilute the incoming feed stream resulting in improved thickener performance through uniform feed dilution and improved flocculation of the feed stream. It also provides a means of de-aeration which can beneficial for flotation streams to reduce froth formation.

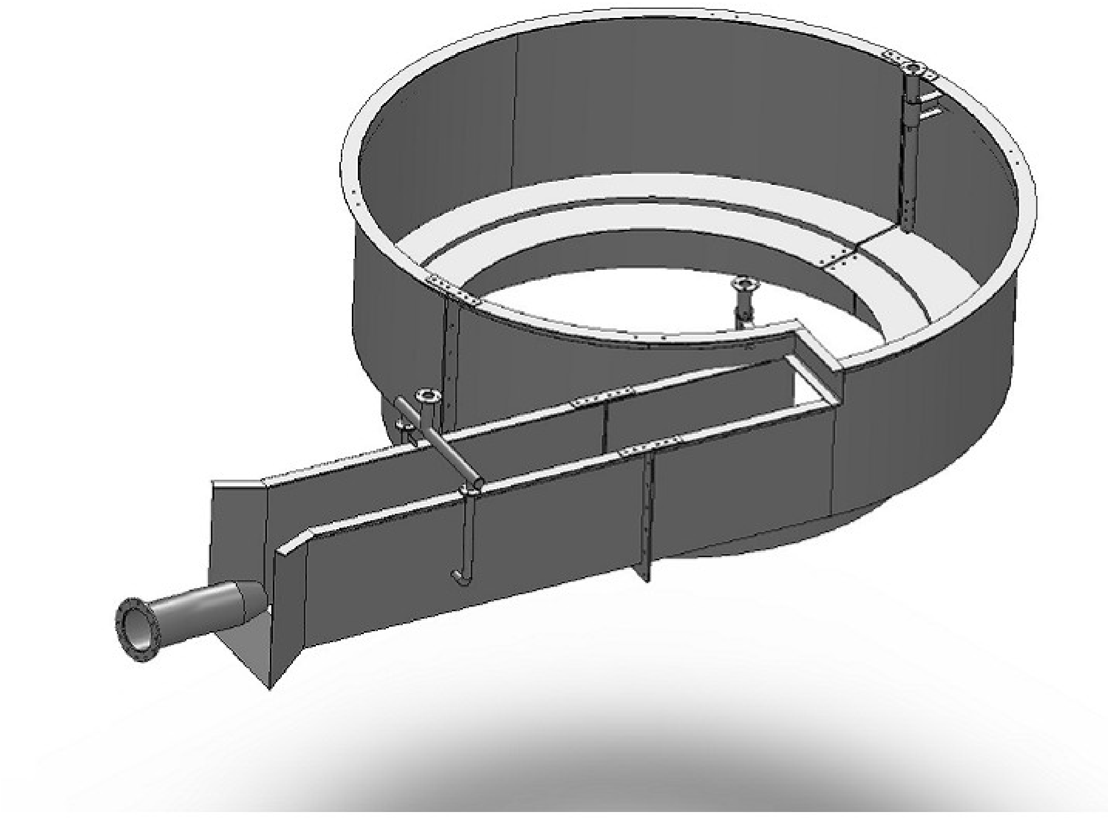


Figure 5.1 – Open Channel EIMCO E-DUC® Feed Dilution System

5.2 Thickener Sizing

Based on the static settling data detailed in Section 4.4, the dynamic settling data detailed in section 4.6, the filter leaf test results, and the underflow slurry yield stress results, the size of High Rate Thickener or alternatively Deep Cone Paste Thickener to process 70 t/h of Browns Range Rare Earth Mineral Tailings sample has been calculated. The results of these calculations are summarised in Table 5.2.

Table 5.2 – Browns Range Rare Earth Mineral Tailings – Thickener Sizing.

Parameter		High Rate Thickener Design Parameters	Deep Cone Thickener Design Parameters
Thickener Feed Rate	**t/h**	70	70
Feed Solids	**% w/w**	50	50
Feed Flow Rate	**m^3/h**	990	990
Feedwell Solids	**% w/w**	5	5
Flocculant Addition Rate	**g/t**	20	20
Mode of Flocculant Addition		Multistage	Multistage
Free Settling Rate	**m/h**	25	25
Rise Rate	**m/h**	2.5	2.5
Overflow Solids	**mg/l**	<200	<200
Underflow Solids	**% w/w**	57 - 59	65 - 68
Underflow Yield Stress	**Pa**	22 - 35	116 – 228
Flux Rate	**t/m^2h**	0.62	0.62
Total Thickener Height	**m**	6.3	9.7
Thickener Diameter	**m**	12 m ϕ	12 m ϕ
Number of Thickeners		1	1

The testwork indicated the feed rate of 70 t/h of Browns Range Rare Earth Mineral Tailings solids can be thickened to an underflow density of 57 - 59 % w/w in a 12 m ϕ High Rate Thickener or to an underflow of 65 - 68 % w/w in a 12 m ϕ Deep Cone Thickener.

APPENDIX 1

Thickener Simulation

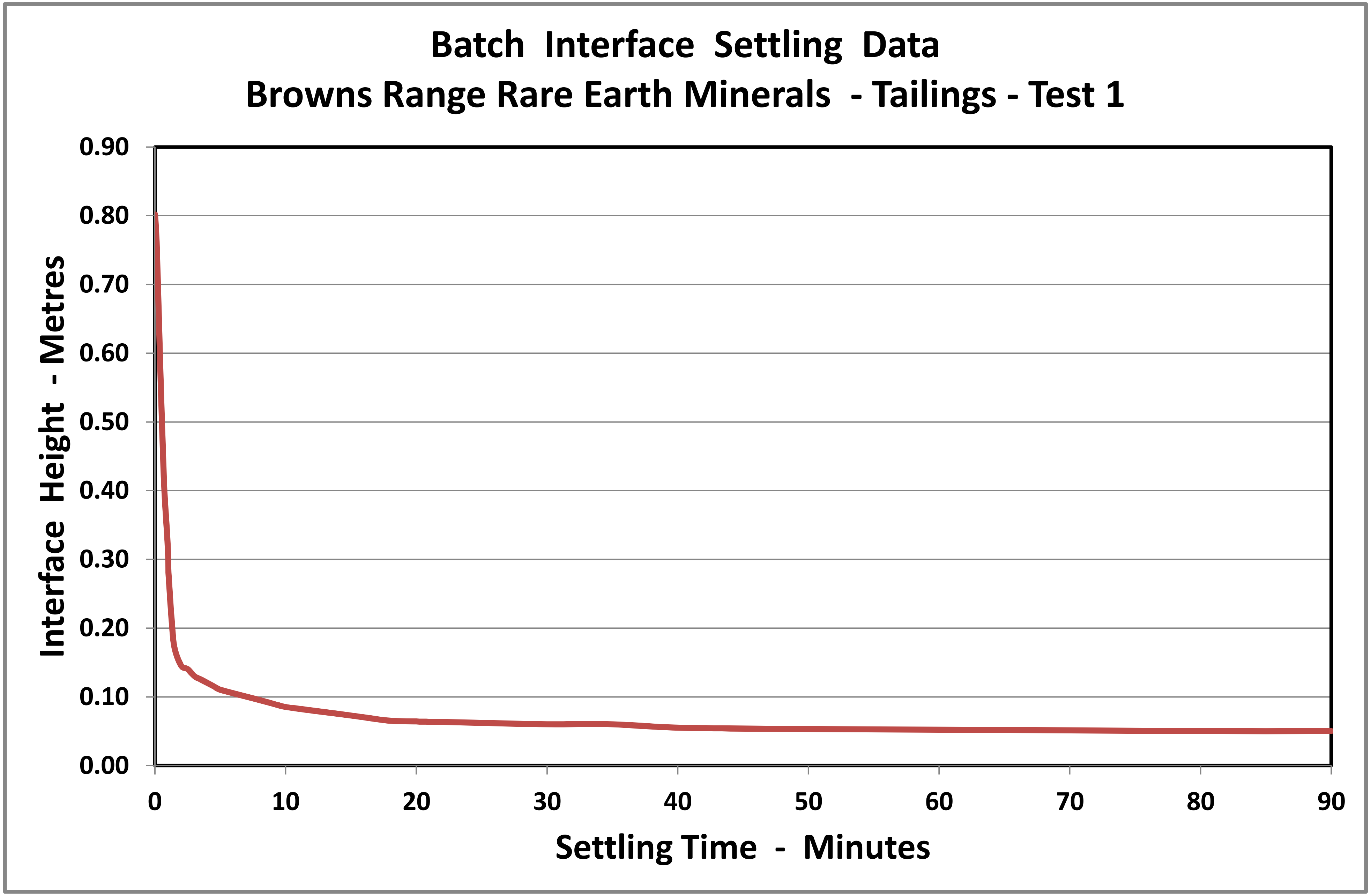
Test Results

Thickener Test Summary for Northern Minerals Browns Range Tailings November 25, 2013

Job:	Browns Range Tailings	Undecanted Slurry Vol (ml):	4000.00	UF % Solids:	Final:	54.62%
Test:	Test 1	Weight (g):	4131.03		Ultimate:	56.09%
Company:	Northern Minerals	Decanted Slurry Vol (ml):	250.00	Init Settling Vel (m/hr):		33.3
Address:	Western Australia	Weight (g):	381.03	Intial Feed Concentration:		5.0%
Material:	Rare Earths	Dry Solids Weight (g):	208.10			
Flocculant:	BASF Magnafloc 5250	Settling Vessel Size (ml/ft):	1520.00			
Concentration (g/l):	0.05	Ultimate Interface Height (ml)	240.00			
Volume Added (ml):	83	Specific Gravity Supernatant:	1.00			
Dosage (g/mt):	20	Specific Gravity Solids:	2.70			
Test Temperature	25oC					

Notes:

Time(min)	Height(ml)	Underflow Weight % Solids	Underflow CU (mt/cu.m)
0	4000	54.62	1.524
0.12	3800	54.00	1.515
0.18	3600	53.00	1.501
0.25	3400	52.00	1.487
0.30	3200	51.00	1.473
0.37	3000	50.00	1.459
0.43	2800	49.00	1.446
0.50	2600	48.00	1.433
0.57	2400	47.00	1.420
0.63	2200	46.00	1.408
0.72	2000	45.00	1.395
0.83	1800	44.00	1.383
0.97	1600	43.00	1.371
1.03	1400	42.00	1.360
1.17	1200	41.00	1.348
1.32	1000	40.00	1.337
1.5	850	39.00	1.325
2	725	38.00	1.315
2.5	700	37.00	1.304
3	650	36.00	1.293
3.5	625	35.00	1.283
4	600	34.00	1.272
4.5	575	33.00	1.262
5	550	32.00	1.252
6	525	31.00	1.243
7	500	30.00	1.233
8	475	29.00	1.223
9	450	28.00	1.214
10	425	27.00	1.205
12	400	26.00	1.196
14	375	25.00	1.187
16	350	24.00	1.178
18	325	23.00	1.169
20	320	22.00	1.161
25	310	21.00	1.152
30	300	20.00	1.144
35	300	19.00	1.136
40	275	18.00	1.128
50	265	17.00	1.120
60	260	16.00	1.112
70	255	15.00	1.104
80	250		


Batch Interface Settling Data
Browns Range Rare Earth Minerals - Tailings - Test 1
Interface Height - Metres
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
10
20
30
40
50
60
70
80
90
Settling Time - Minutes

APPENDIX C
Limitations

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