SHREE MINERALS LTD

Nelson Bay River Project

Hematite and Magnetite Process Review

CONFIDENTIAL

Project No: J491

Date: July 2011

Document No: J491-RP-000-001 0

Mineral Engineering
Technical Services Pty Ltd

ABN: 66 009 357 171

Postal Add: PO Box 3211
Perth, WA 6832
Phone: +61 8 9421 9000
Facsimile: +61 8 9325 8311
Web: www.mets.net.au

Damian Connelly
Director/Principal Consulting Engineer
Chartered Professional Engineer (MET)

Email: damian.connelly@mets.net.au

CONFIDENTIALITY

This document and its contents, including work scope, methodology and commercial terms will be treated in strict confidence by **Shree Minerals Ltd** and the contents will be used by **Shree Minerals Ltd** only for their own use.

Passing of this document to a third party, duplication or re-use of this document, in whole or part, electronically or otherwise, is not permitted without the expressed written consent of Mineral Engineering Technical Services Pty Ltd. This written consent is hereby given by Mineral Engineering Technical Services Pty Ltd to **Shree Minerals Ltd.**

DISCLAIMER

With respect to all the information contained herein, neither Mineral Engineering Technical Services Pty Ltd, nor any officer, servant, employee, agent or consultant thereof make any representations or give any warranties, expressed or implied, as to the accuracy, reliability or completeness of the information contained herein, including but not limited to opinions, information or advice which may be provided to users of the document.

No responsibility is accepted to users of this document for any consequence of relying on the contents hereof.

J491 – SHREE MINERALS LTD							
REV	**DESCRIPTION**	**ORIG**	**REVIEW**	**APPROVAL**	**DATE**	**CLIENT APPROVAL**	**DATE**
A	Issued for Internal Review	E.Hodgson		N/A		N/A	
B	Issued to client as draft	J. West	J. Visser D.Connelly				
0	Issued to Client		J. Visser D. Connelly D.Walker	N/A			

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. EXECUTIVE SUMMARY

Nelson Bay River Iron Project owned by Shree Minerals Ltd has published a resource comprising three types of ore:

1. Direct Shipping Ore
2. Beneficial goethitic hematite ore and
3. Magnetite Ore

Mineral Engineering Technical Services (METS) were requested by Shree Mineral Limited to:

- Develop conceptual process flow sheets to characterise and determine a process of direct shipping ore (DSO) and beneficiation of their goethitic hematite ore that makes up the capping of the Nelson Bay River iron ore deposit in North West Tasmania.
- Review the proposed conceptual magnetite flowsheet, modify it to include a High Pressure Grinding Roll (HPGR) instead of secondary and tertiary crushing and conduct testwork to establish the amenability of the magnetite ore to HPGR.

A number of physical ore characterisation tests were carried out on the hematite/goethite ore which were; unconfined compressive strength, crushing work index, bond abrasion index and drop tower test. The results of these tests indicated that the ore was typical of an iron ore of this nature and would be amenable to crushing and producing lump ore. Beneficiation work, specifically jigging and tabling, was included in the testwork programme and showed some promise of a way forward. It is believed that a direct shipping ore could be produced by delineating the High Grade Zone by drilling & by appropriate grade control during mining.

A High Pressure Grinding Roll test was conducted on the composite sample of magnetite. It indicated that the machine would be suitable for comminution of the magnetite but more comprehensive testwork will be required to define operating parameters.

Conceptual process flow diagrams were generated for processing each of the three ore types including an alternative flowsheet for magnetite, which incorporated a HPGR. More detailed testwork is recommended in the next stage of study, to confirm the validity of these process flow diagrams for variability in the orebody.

A preliminary mass balance was conducted on the proposed magnetite circuit using data supplied from earlier testwork. The final product from the preliminary mass balance achieved a grade of 68.2% Fe and 4.7% SiO_2 at a mass yield of 36%.

A CAPEX estimate of between $10.4 million and $13.7 million is proposed for the magnetite plant depending on the number of second hand equipment utilised.

The OPEX for the magnetite has been estimated at $3.6 million per annum or $8.93/ tonne of ore treated. It does not include administration and mining costs.

The battery limits set for these estimates are for the magnetite circuit, including the HPGR feed bin and the downstream limit set at the TSF and concentrate tanks.

2. RECOMMENDATIONS

METS recommends the following:

- Further drilling to delineate the high grade DSO zone
- Further testwork is required on the LG material to determine its upgrade potential
- HLS tests at a medium density of 3.5, 3.8 and 4.1 should be carried out on the LG fines and lump. Lump samples need to be collected and sent to a laboratory for testwork
- Upflow classifier testwork should be carried out on the -1mm LG fines, deslimed at 75µ
- Testwork to validate the preliminary mass balance for magnetite processing should be carried out
- More comprehensive HPGR testing is required to define operating parameters

3. INTRODUCTION

The Nelson Bay River Project deposit is located approximately 70 km south west of Smithton in the north west of Tasmania (Figure 3-1).

Figure 3-1: Location of Nelson Bay River Project

The ore body was identified over 40 years ago and first drilled in the late 1960's.
The testwork conducted to date has focussed on the magnetite portion of the resource. The deposit was only drilled in 2009 to determine the extent of the hematite/goethite ore.

The published Resources by Shree Minerals are as follows:

Table 3-1: Goethite-Hematite Resources at Nelson Bay River Iron Project

Area	Mass (Mt)	Grade (%)							Remarks
		Fe	SiO_2	Al_2O_3	P	S	LOI	Fe (Cal)	
NBR South	0.5	57.8	8.8	1.4	0.06	0.03	6.3	61.7	DSO
NBR North	0.7	46.8	23.7	2.7	0.02	0.07	4.7	49.1	Beneficiable material
Total	1.2	51.0	18.0	2.2	0.04	0.05	5.3	53.9	

Note: The resource estimate is estimated at 30% Fe cut off and with an average density of 3 t/m^3; The Fe (Cal) grade is the calcined iron grade with the loss on ignition material removed from the block grade value [Fe(Cal) = Fe/ (100-LOI)]. The resources are of Inferred Category.

Table 3-2: Magnetite Resources at Nelson Bay River Iron Project

Resource Category	Mass (Mt)	Mag% (DTR)	Contained Magnetite (Mt)
Indicated	1.7	38.5	0.7
Inferred	6.1	38.2	2.3
Total	**7.8**	**38.3**	**3.0**

Note: The resource estimate is based on 20% magnetite (DTR) cut off and with an average density of 3.71 t/m3. DTR = Davis Tube Recovery

Mr Sanjay Loyalka, Chairman of Shree Minerals Ltd (Shree) requested that Mineral Engineering Technical Services (METS) design and co-ordinate metallurgical testwork to assess the potential of the hematite contained in the orebody at Nelson Bay River as a direct shipping ore (DSO) and make recommendations for processing options.

For the magnetite portion of the orebody a review of the existing magnetite process flowsheet, co-ordination of additional testwork to determine the requirements for HGPR and possible modifications to the flowsheet was agreed to.

4. SCOPE OF WORK

4.1 Hematite

The objective of this work was to determine whether the quality of the “lower grade” hematite ore could be easily processed to produce a DSO ore.

Two grades of hematite ore were identified in the drilling program, high grade and low grade ore. These grades correspond generally to the North and South areas of the orebody. It was apparent from the higher grade material that very little or no processing of ore would be needed to achieve a marketable product.

4.2 Magnetite HPGR Testwork and Flowsheet Review

A conceptual sketch of a proposed processing circuit for the magnetite ore was developed during previous testwork. It did not include a HPGR. The purpose of this testwork was to establish the suitability and parameters for inclusion of a HPGR in the magnetite processing circuit.

5. HEMATITE ORE

5.1 Testwork Description

A staged approach was taken to conducting the testwork on the hematite ore with each stage of the testwork program only progressing after results from previous stages of testwork showed that further work was necessary.

The purpose of the testwork was to:

- Predict the final lump/fine split and particle size distribution expected from the blasting and processing of an ore
- Define the characteristics of lump and fines ores and thus determine if any beneficiation testwork is required
- Determine the comminution characteristic of the ore
- Determine a suitable beneficiation method(s) for high and low grade ores if required

5.2 Testwork Results and Analysis

5.2.1 Unconfined Compressive Strength

The UCS testwork was conducted on the 366403 sample (HG).

Unconfined Compressive Strength (UCS) is a measure of the strength of intact rock under compressive load. It is the maximum compressive stress a sample can withstand before failure. The strength, measured in MPa, is vital for the selection of crushers and in assessing the suitability of an ore for milling.

In the context of processing, the UCS value is interpreted as follows:

Property	Very strong	Strong	Moderately strong	Weak
UCS (MPa)	>200	60-200	20-60	<20

The UCS value was determined to be 32.2 MPa. This indicated that the ore is moderately strong, a normal finding of iron ore type deposits. There should not be any concerns in terms of the selection of crushers. However, this testwork was only conducted on one sample and

METS recommends that a future testwork program look at variation through the whole ore body.

Details of the UCS testwork can be found in Appendix B.

5.2.2 Crushing Work Index

The crushing work index (CWi) testwork was conducted only on the low grade ore. METS recommends that a future testwork program incorporate other ore types, i.e. different drill holes, high grade ore, etc.

The CWi, measured in kWh/tonne, is used to calculate the power requirements for primary crushing. The work index is calculated from the energy required to fracture the rock, the thickness of the rock and its specific gravity.

In the context of processing, the CWi value is interpreted as follows:

Property	Very hard	Hard	Medium	Soft	Very Soft
CWi (kWh/t)	>20	14-20	9-14	7-9	<7

An average CWi of 9.5 kWh/tonne was determined from testing the Shree sample. This result indicates that the power requirement should not be too high.

Details of the CWi testwork can be found in Appendix C.

5.2.3 Bond Abrasion Index

The Bond abrasion index (Ai) testwork is used to determine the abrasiveness of a test sample. The index is used to determine wear rates of liners and media consumption. Such wear indications are needed to give accurate operating cost estimates.

In the context of processing, the Ai value is interpreted as follows:

Property	Non Abrasive	Moderate Abrasive	Abrasive	Highly Abrasive
Ai	<0.1	0.1-0.3	0.3-0.5	>0.5

The Bond abrasion testwork was performed on both the HG and LG ores. The results are summarised in Table 5-1.

Table 5-1: Ai Results – Summary

	HG	LG
Ai	0.1846	0.1623

The Ai results indicate that the tested ores were moderately abrasive. The wear rates of liners and media consumption should not be too high.

Details of the Ai testwork results can be found in Appendix D.

5.2.4 Drop Tower Test

The purpose of the Drop Tower Test is to predict the final lump/fine split and particle size distribution expected from the blasting and processing of an ore.

The test results are summarised in Table 5-2.

Table 5-2: Drop Tower Test Results

SAMPLE	**SIZING**			**% Lump**	**% Fines**	**Total**
	+6.3mm	**-6.3mm**	**Total**	**+6.3mm**	**-6.3mm**	**Total**
Composite - HG	(kg)	(kg)	(kg)			
Crushing on CSS 31mm	74.80	14.56	89.36	83.71	16.29	100.00
After 5 Drops (+6.3)	60.20	13.96	74.16	81.18	18.82	100.00
Total for Testwork	60.20	28.52	88.72	67.85	32.15	100.00

Bulk handling of the Nelson Bay River ore should not have any issues due to the high ratio of lump to fine split.

The particle size distribution (PSD) of the lump and fines size factions are summarised in Table 5-3, Table 5-4 and Figure 5-1 to Figure 5-4.

Details of the Drop Tower Test can be found in Appendix E.

As can be seen from Table 5-3 and Figure 5-1, the -31+25 and -25+20 mm size fractions made up the highest percentage of overall mass for the lump portion.

Table 5-3: Particle Size Distribution (PSD) for Lump

Sample No.	Screen Size (mm)	Screen Weight (kg)	Weight (%)	Cum. % Passing
LUMP	-31+25	1.19	24.84	100.00
	-25+20	1.13	23.59	75.16
	-20+15	0.93	19.42	51.57
	-15+10	0.87	18.16	32.15
	-10+8	0.31	6.47	13.99
	-8	0.36	7.52	7.52
	Total	4.79	100.0%	

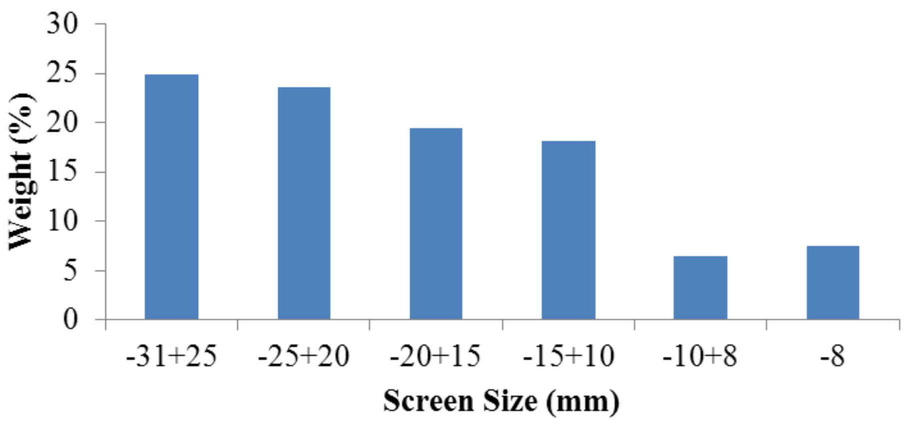


Figure 5-1: Weight Percentage for Different Sizes – Lump

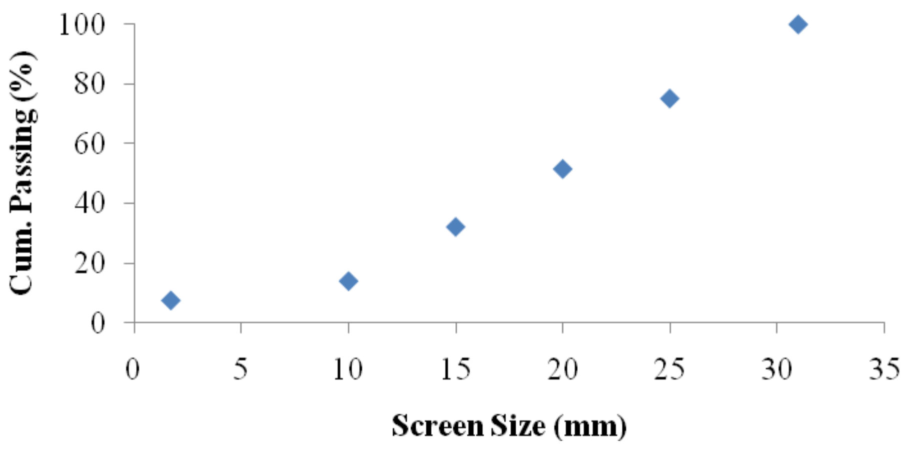


Figure 5-2: Cumulative Size Distribution of Lump Fraction

As can be seen in Table 5-4 and Figure 5-3 the -6.3+3.35 and -3.35+1.18 mm fractions made up the highest percentage of overall mass in the fines.

Table 5-4: Particle Size Distribution (PSD) for Fines

Sample No.	Screen Size (mm)	Screen Weight (g)	Weight (%)	Cum. Passing
FINES	-6.30+3.35	524.30	26.15	100.00
	-3.35+1.18	504.30	25.15	73.85
	-1.18+0.60	230.70	11.51	48.70
	-0.60+0.30	215.10	10.73	37.19
	-0.30+0.15	193.00	9.63	26.46
	-0.15+0.090	115.70	5.77	16.83
	-0.090+0.075	74.80	3.73	11.06
	-0.075	147.00	7.33	7.33
	Total	2004.90	100.00	

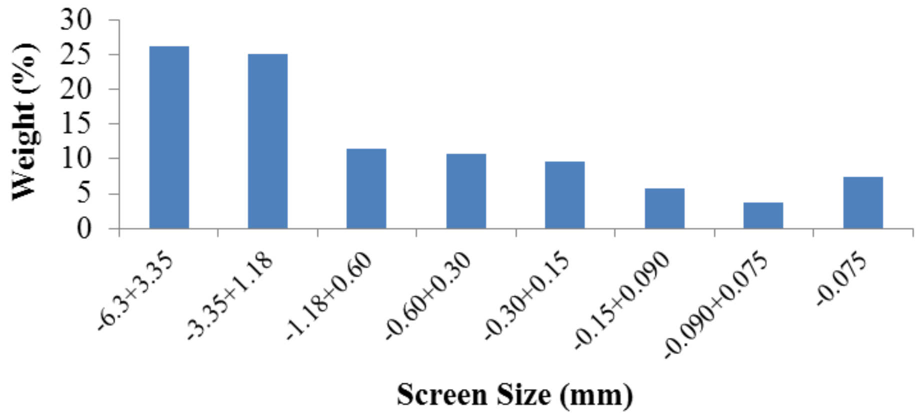


Figure 5-3: Weight Percentage for Different Sizes – Fines

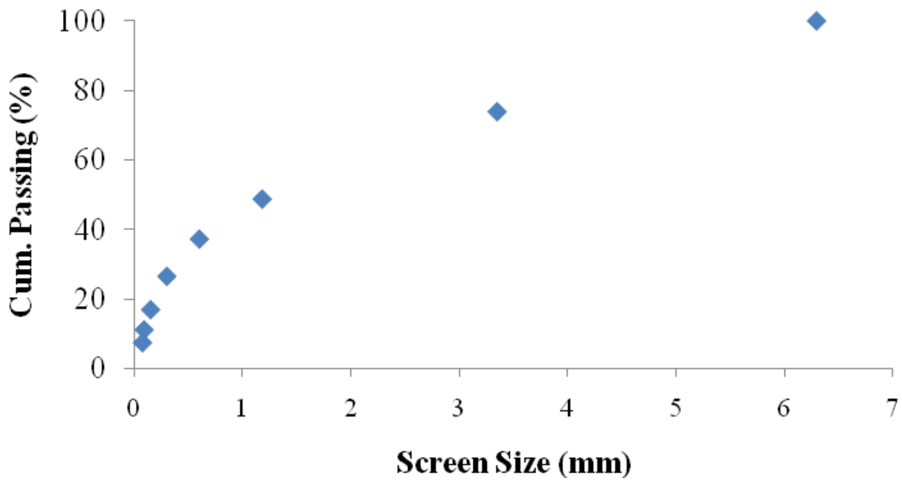


Figure 5-4: Cumulative Size Distribution – Fines

5.3 Jig Separation

5.3.1 Lower Grade Ore

Due to higher levels of silica present (> 7% silica), the fines did not meet the expected grade. This testwork was conducted on the fines to determine the suitability of jig separation in rejecting the impurities in the ore.

No LG lump data has been supplied for analysis.

The Jig results are summarised in following tables:

Table 5-5: Jig Separation Results – (-6.3+3.35mm)

Jig Stratification Results - LOWER GRADE FINES (-6.3+3.35mm)													
Jig Strata		Mass Weight (g)	Mass (%)	Fe Grade (%)	Fe DISTn. (%)	SiO_2 Grade (%)	SiO_2 DISTn. (%)	Al_2O_3 Grade (%)	Al_2O_3 DISTn. (%)	P Grade (%)	P DISTn. (%)	S Grade (%)	S DISTn. (%)
PRODUCTS	1	1164.6	20.7	61.20	22.3	5.82	11.0	0.34	13.0	0.05	214.8	0.013	2.0
	2	778.1	13.8	58.00	14.1	8.72	11.0	0.43	11.0	0.06	165.6	0.013	1.3
	3	664.3	11.8	57.30	11.9	10.10	10.9	0.44	9.6	0.06	150.8	0.014	1.2
	4	772.7	13.7	56.30	13.6	11.00	13.8	0.55	13.9	0.06	175.4	0.015	1.5
	5	859.2	15.2	56.20	15.1	10.90	15.2	0.52	14.7	0.07	207.3	0.015	1.7
	6	652.5	11.6	55.00	11.3	12.50	13.2	0.61	13.1	0.07	159.7	0.016	1.4
	7	477	8.5	51.30	7.7	18.10	14.0	0.89	13.9	0.07	111.7	0.020	1.3
	8	269.7	4.8	45.80	3.9	24.80	10.9	1.23	10.9	0.07	63.1	0.027	1.0
Calc'd HEAD		**5638.1**	**100.0**	**56.57**	**100.0**	**10.93**	**100.0**	**0.54**	**100.0**	**0.06**	**1248.4**	**0.015**	**11.4**

Table 5-6: Jig Separation Results – Fines

Jig Stratification Results - LOWER GRADE FINES (-3.35+1.00mm)													
Jig Strata		Mass Weight (g)	Mass (%)	Fe Grade (%)	Fe DISTn. (%)	SiO_2 Grade (%)	SiO_2 DISTn. (%)	Al_2O_3 Grade (%)	Al_2O_3 DISTn. (%)	P Grade (%)	P DISTn. (%)	S Grade (%)	S DISTn. (%)
PRODUCTS	1	1834.2	27.8	60.20	29.9	6.86	15.7	0.40	19.4	0.06	322.1	0.014	3.1
	2	1485.6	22.5	57.00	22.9	10.10	18.7	0.54	21.2	0.07	301.3	0.016	2.9
	3	1595.9	24.2	55.70	24.0	12.20	24.3	0.58	24.5	0.07	333.4	0.018	3.5
	4	1273.7	19.3	53.40	18.4	16.00	25.4	0.65	21.9	0.07	273.8	0.018	2.8
	5	416.7	6.3	42.50	4.8	30.60	15.9	1.18	13.0	0.07	93.4	0.021	1.1
Calc'd HEAD		**6606.1**	**100.0**	**55.97**	**100.0**	**12.14**	**100.0**	**0.57**	**100.0**	**0.07**	**1323.9**	**0.017**	**13.2**

Although these results are not totally conclusive, they do indicate the possibility of further processing to improve the minor element components. The Fe analysis appears satisfactory in approximately half of the mass of the resultant streams. These can be taken as scout tests just to test the samples available and were conducted on the lower grade samples adjacent to the boundary of the high grade/ low grade ore designation.

Further drilling will need to be conducted to obtain suitable HG samples or near HG samples to investigate this further.

5.3.2 Heavy Liquid Separation

Heavy liquid separation testwork was conducted on the -6.30 mm material of the lower grade ore that was used in the jig tests. This was to assist in determining the beneficiation characteristics. The testwork results are summarised below.

Table 5-7: Heavy Liquid Separation Results

SHREE MINERALS - HLS TESTWORK ON LOWER GRADE COMPOSITE -6.3+1mm FRACTION													
			WEIGHT	Fe		SiO_2		Al_2O_3		P		S	
SIZE FRACTION (mm)	SG FRACTION	SCREEN WEIGHT (g)	Fraction DISTn. (%)	Fe Grade (%)	Fe DISTn. (%)	SiO_2 Grade (%)	SiO_2 DISTn. (%)	Al_2O_3 Grade (%)	Al_2O_3 DISTn. (%)	P Grade (%)	P DISTn. (%)	S Grade (%)	S DISTn. (%)
-6.3+1.0	<2.86	9.4	4.0	23.20	1.6	56.60	20.2	4.23	24.3	0.04	34.6	0.033	1.0
	2.86-2.96	1.8	0.8	44.60	0.6	27.10	1.8	1.25	1.4	0.06	8.4	0.024	0.1
	2.96-3.3	23.0	9.7	47.40	8.1	22.10	19.3	1.03	14.5	0.06	121.1	0.030	2.2
	>3.3	203.4	85.6	59.20	89.7	7.61	58.7	0.48	59.8	0.07	1138.5	0.017	11.1
	Calc'd HEAD	237.6	100.0	56.52	100.0	11.10	100.0	0.69	100.0	0.07	1302.5	0.019	14.5
ASSAY HEAD				**56.30**		**11.70**		**0.72**		**0.07**		**0.019**	

HEAVY LIQUID SEPARATION - LOWER GRADE COMPOSITE -1.0 +0.045mm FRACTION													
			WEIGHT	Fe		SiO_2		Al_2O_3		P		S	
SIZE FRACTION (mm)	SG FRACTION	SCREEN WEIGHT (g)	Fraction DISTn. (%)	Fe Grade (%)	Fe DISTn. (%)	SiO_2 Grade (%)	SiO_2 DISTn. (%)	Al_2O_3 Grade (%)	Al_2O_3 DISTn. (%)	P Grade (%)	P DISTn. (%)	S Grade (%)	S DISTn. (%)
-1+0.045	<2.86	15.1	9.5	14.30	2.5	73.40	48.6	2.47	26.5	0.03	31.1	0.018	1.7
	2.86-2.96	6.7	4.2	43.80	3.4	26.60	7.8	1.97	9.4	0.08	34.9	0.032	1.3
	2.96-3.3	6.9	4.3	41.00	3.2	31.70	9.6	2.15	10.5	0.07	31.5	0.029	1.2
	>3.3	130.1	81.9	60.90	90.9	5.96	34.0	0.58	53.6	0.07	544.4	0.026	21.1
	Calc'd HEAD	158.8	100.0	54.88	100.0	14.36	100.0	0.89	100.0	0.06	641.9	0.026	25.3
ASSAY HEAD				**54.62**		**14.34**		**0.94**		**0.06**		**0.021**	

These results indicate that there is a probability of beneficiating this material to produce a saleable product. More than 80% of the mass produces a saleable Fe grade material with the contaminant materials just above acceptable limits. Further beneficiation testwork is warranted on new samples.

5.4 Hematite Processing Recommendations

There are two distinct grade areas contained within the Nelson Bay River Hematite deposit. Based on the preliminary testwork conducted as part of this testwork programme it is recommended that the higher grade material be prepared as a direct shipping ore with consideration to the variability in the orebody. Careful selectivity will be required to achieve a saleable grade without major processing. Further drilling of the high grade pod should be considered to delineate the zone that is representative of the material as a DSO with little preparation required.

The process flow sheets presented are capable of processing up to 20 Mt/a of feed to the plant.

The abrasion index points to a sizer replacing the primary gyratory crusher. The benefits of this change are threefold. The costs (OPEX and CAPEX) of a mineral sizer are significantly less than that cost of a gyratory for ore with an abrasion index of this nature. The circuit will not require a tertiary crushing stage and the lump particles from the sizer are usually more competent than those processed through 3 stages of crushing.

The low grade hematite for the other area of the deposit will require beneficiation. Further testwork is required in order to recommend a processing route for beneficiation of this ore.

The preliminary flowsheets for high and low grade hematite can be found in Figure 5-5 and Figure 5-6. Testwork will be required to confirm the flowsheets in the next study level.

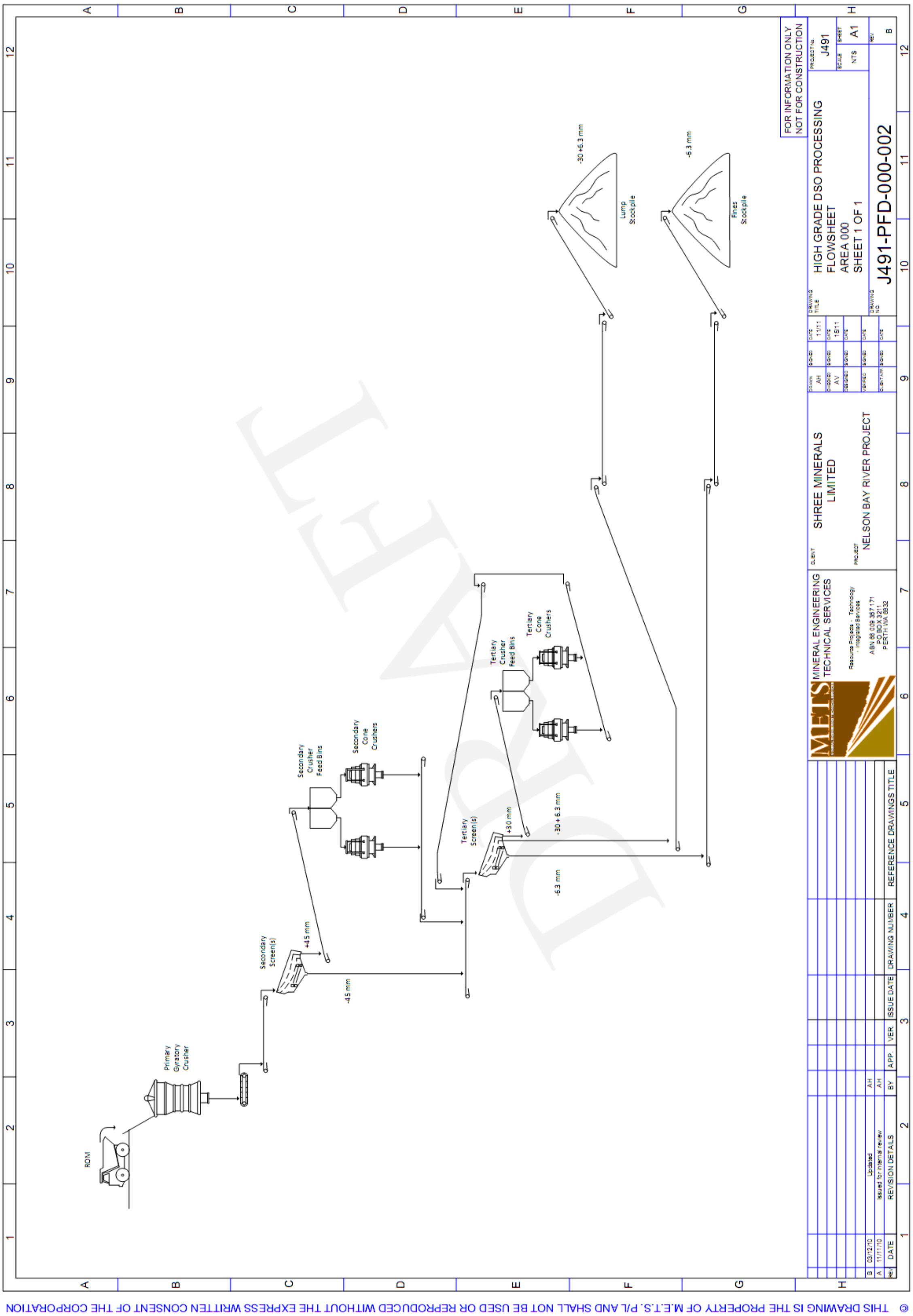


Figure 5-5: High Grade Hematite Flowsheet

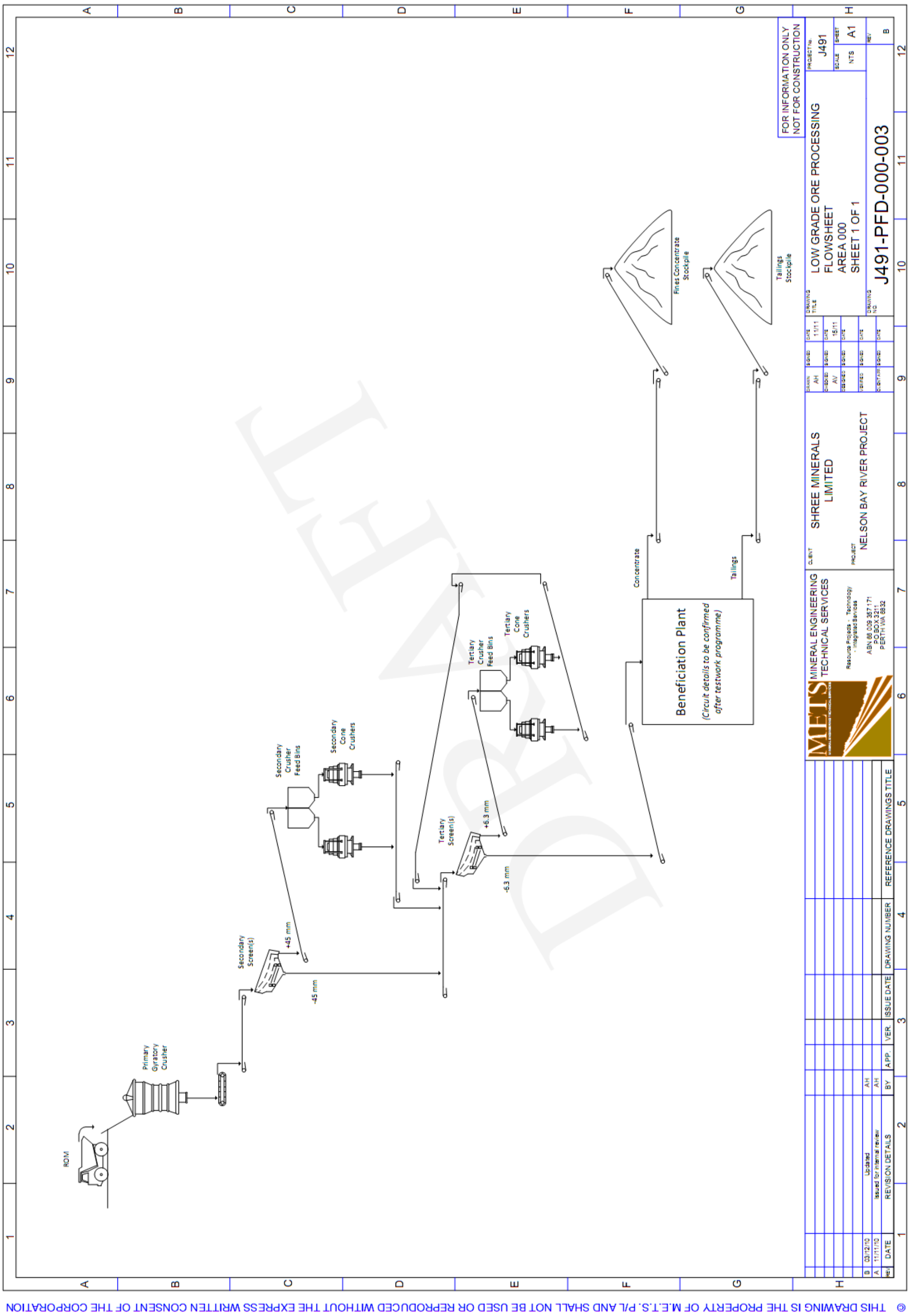


Figure 5-6: Low Grade Hematite Flowsheet

6. MAGNETITE REVIEW

6.1 Shree's Magnetite Flowsheet Review

The supplied conceptual flowsheet is shown below in Figure 6-1. Aside from a few key points, at a conceptual study level the supplied flowsheet is on the whole valid. The few key points of discussion are:

- It is generally not accepted practise to incorporate a recycle stream to the primary or the secondary crusher
- The tertiary crusher is indicated as a cone crusher. Typically 3 mm is very fine for a crusher product of this type
- Recycling the screened +0.7 mm magnetic stream back to the tertiary crusher is a poor design. This would reduce the capacity of the crusher by lowering voidage, required for effective crushing and could cause clogging

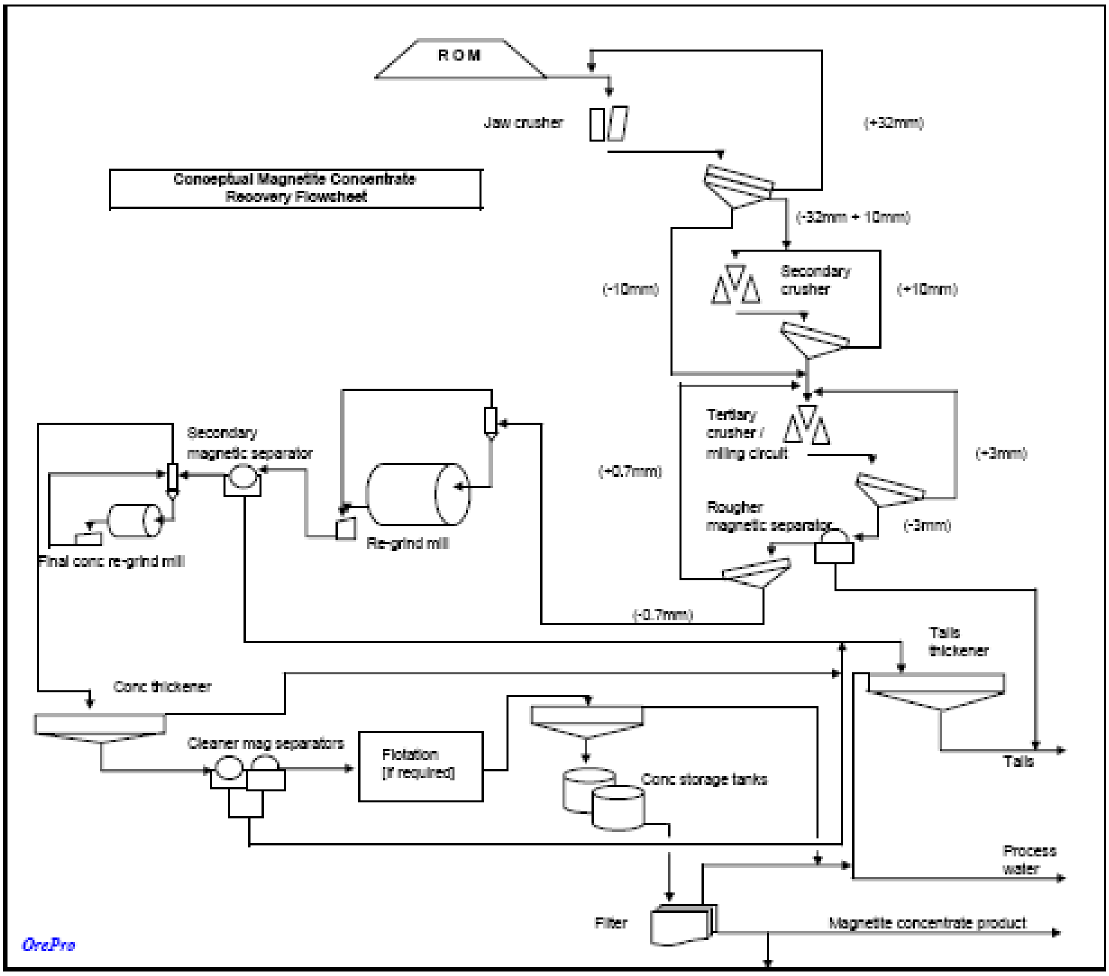


Figure 6-1: Supplied Conceptual Magnetite Flowsheet

A High Pressure Grinding Roll crusher (HPGR) was proposed to replace the tertiary crushing stages in the original conceptual flowsheet. It is believed that replacing the tertiary crushers with an HPGR would be more economical and less energy intensive and is expected that it would achieve the 3mm crush size. However, this would depend on the amenability of the ore to HPGR.

6.2 Metallurgical Testwork

6.2.1 HPGR Testplan

The metallurgical testplan for the assessment of the amenability of Shree's magnetite ore to HPGR crushing is shown in Figure 6-2.

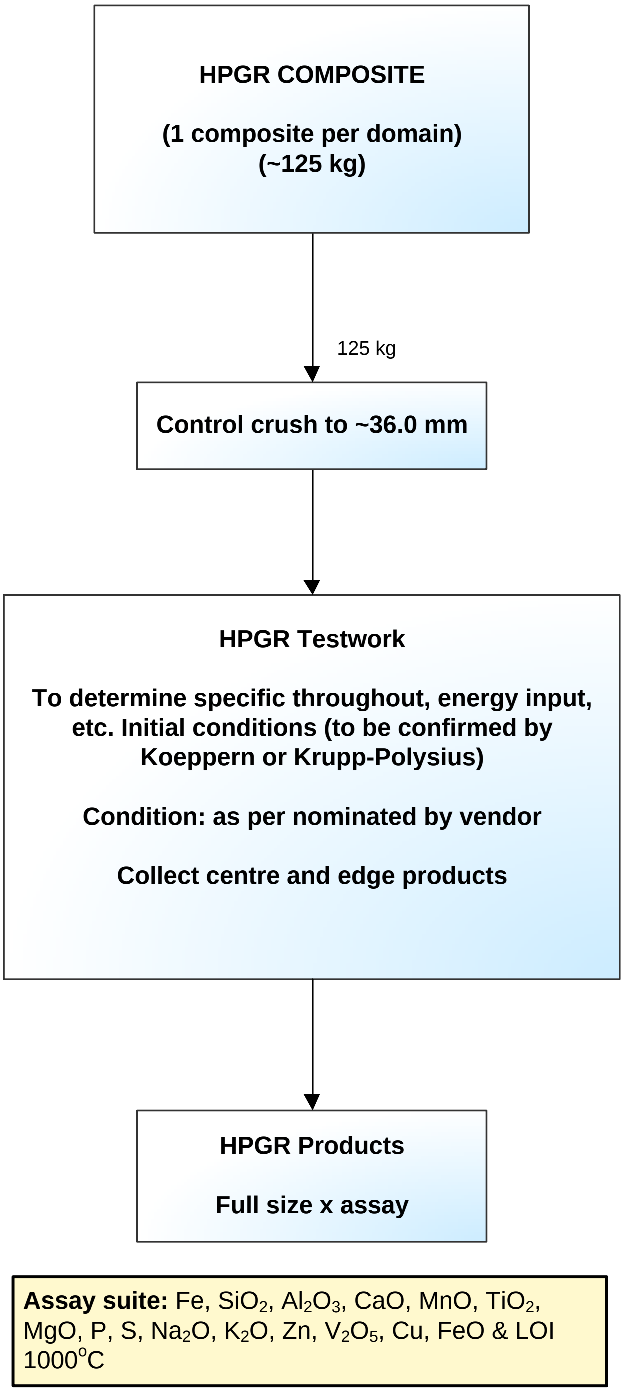


Figure 6-2: HPGR Testplan

6.2.2 Sample Selection and Compositing

A sample of magnetite drill core for HPGR testwork was selected based on consultation with Shree and sample availability. The selected samples are shown in Table 6-1.

Table 6-1: Magnetite Samples for HPGR Testing

Hole ID	Depth from, m	Depth to, m	Interval, m	Core Size
NBR003	148	167	19	1/4
NBR004	160	177	17	1/4
NBR007	55	77	22	1/4
NBR008	94	108	14	1/4
NBR018	51	77	26	1/2
NBR021	132	165	33	1/2

6.2.3 HPGR Testwork Result

The full testwork report is attached in Appendix G. The test was conducted to determine whether a HPGR unit would be suitable for Shree's magnetite ore.

Only a single test could be conducted due to the insufficient mass of the feed. Feed sizing indicated a truncated material where the fines fractions appeared to be depleted. This has a negative effect on the HPGR's performance. However, promising results were obtained.

It was not possible to obtain the required data for parameter modelling but an assessment of the comminution performance indicated promising results. Further testwork is required to complete this work.

A final comment in the appended report states:

- "The main observations during this testwork programme are:
  - Significant size reduction through HPGR comminution were measured
  - A specific pressing force of 3,000 kN/m2 were tested only – this pressing force proved reasonably efficient but not necessarily optimal
  - Specific energy consumption was within expected range, albeit on the higher side, for the applied pressing forces
  - Further testing is justified

This test work program conducted on the ore sample as provided by METS demonstrated that the ore responds well to the high pressure comminution process. We strongly recommend that a full test work program is conducted for this project."

6.3 Alternative Flowsheet

6.3.1 Flowsheet

An alternative magnetite flowsheet, including HPGR comminution, can be found in Figure 6-3.

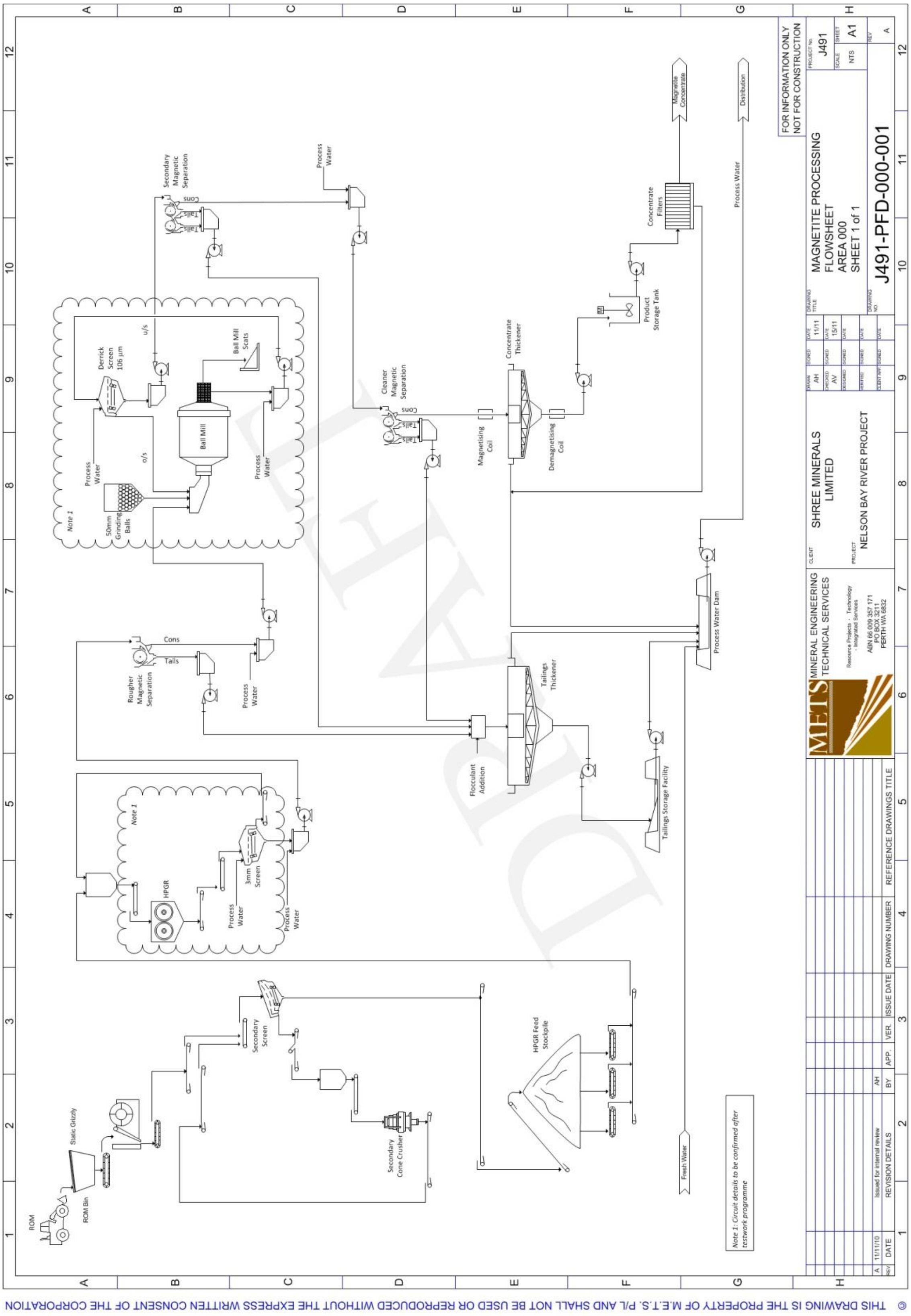


Figure 6-3: Alternative Magnetite Flowsheet

6.3.2 Process Description

420,000 tpa of ROM ore is crushed in the primary jaw crusher. The primary crushed ore is conveyed to the secondary screens for screening. Typically the material would be screened at a cut size of 40 mm; however this needs to be confirmed with detailed testwork.

The oversize (+40 mm) ore from the secondary screen is conveyed to the secondary cone crushers. The crushed product is conveyed back to the secondary screens.

The secondary screen undersize (-40.0 mm) ore is conveyed to a buffer stockpile ahead of the high pressure grinding rolls (HPGRs). The purpose of the stockpile is to disengage the crushing and grinding sections, which have different operating availabilities.

Ore is removed from the stockpile by reclaim ore feeders and conveyed to a series of bins to feed the three lines of HPGRs.

The ground HPGR product is screened at 3 mm. This size is an estimate based on METS' experiences with other iron ore HPGR circuits and should be confirmed with testwork. The oversize is recycled to combine with the fresh feed and reprocessed through the HPGRs. The undersize (-3 mm) is slurried with water and pumped to the first stage of magnetic separation, the rougher wet low intensity magnetic separators (rougher wet LIMS).

The rougher wet LIMS separate the -3 mm ground product into magnetic concentrates (cons) and non-magnetic tailings (tails) streams. The tails are pumped to the tails thickener, reducing the tonnage to be further milled in the ball mills.

The rougher cons are re-slurried with water and pumped to the ball mills. Grinding balls are added on an "as needs" basis.

The mill product is screened to remove ball scats and other oversize detritus and the undersize is pumped (with additional process water added if required) to Derrick screens for screening at 106 µm. This yields an estimated screen undersize product, P_{80} of ~75 µm.

The oversize (+106 µm) is recycled to the ball mills for regrinding.

The -106 µm pulp is pumped to the secondary LIMS for further magnetic concentration and is then re-slurried and pumped to the cleaner wet LIMS for final magnetic concentration.

The secondary wet LIMS units separate the -106 µm ground product into mags (cons) and non-mags (tails) streams.

The cleaner wet LIMS concentrate, at an approximate grade of 68% Fe is repulped with process water and pumped to the concentrate thickener for partial dewatering.

The thickener underflow at 65% w/w solids is pumped to the concentrate storage tank, ready for transport to the port via the concentrate slurry pipeline. This transportation method needs to be confirmed by the following study stage through an infrastructure study.

The secondary wet LIMS and cleaner wet LIMS non-mag tails are pumped to the tailings thickener, combining with the rougher LIMS non-mag tails, are thickened and pumped to the tailings storage facility.

The tailings thickener overflow and concentrate thickener overflow flow by gravity to the process water dam for use in the operations.

6.3.3 Basic Mass Balance

A basic mass balance for the alternative flowsheet was developed based on the inputs and assumptions summarised in
Table 6-2.

The mass balance provides important information, such as the solids and water entering the plant, recoveries of iron and silica at each of the magnetic separation stages and the overall recovery.

Table 6-2: Mass Balance Inputs

Inputs	Unit	Quantity	Comments
Throughput	tpa	420,000	Assumed
Head Grades	% Fe	40.9	Shree Minerals Mining Lease Report
	% SiO_2	22.6	To be confirmed by testwork/ client data
Ore moisture	%	2.5	Assumed
Crushing Availability	%	70	Assumed
	hours	6,132	Calculation
Concentrator Availability	%	90	Assumed
	hours	7,884	Calculation
Secondary crusher recirculating load	%	150	Assumed
HPGR recirculating load	%	100	Assumed
Ball mill recirculating load	%	200	Assumed
HPGR o/s density	% w/w	95	Assumed
Ball mill feed density	% w/w	65	Assumed
Inputs	Unit	Quantity	Comments
Tailings thickener u/f density	% w/w	60	Assumed
Concentrate thickener u/f density	% w/w	65	Assumed
Concentrate filter cake density	% w/w	90	Assumed
LIMS feed density - all units	% w/w	30	Assumed
LIMS con density - all units	% w/w	60	Assumed
Rougher LIMS			
Mass recovery	%	60.5	To be confirmed by testwork/ client data
Iron recovery	%	80.0	To be confirmed by testwork/ client data
Silica recovery	%	50.0	To be confirmed by testwork/ client data
Secondary LIMS			
Mass recovery	%	70.0	To be confirmed by testwork/ client data
Iron recovery	%	80.0	To be confirmed by testwork/ client data
Silica recovery	%	40.0	To be confirmed by testwork/ client data
Cleaner LIMS			
Mass recovery	%	85.0	To be confirmed by testwork/ client data
Iron recovery	%	93.8	To be confirmed by testwork/ client data
Silica recovery	%	37.5	To be confirmed by testwork/ client data
Overall recovery			
Mass recovery	%	36.0	Average of preliminary DTR testwork results – client supplied
Iron recovery	%	60.0	Average of preliminary DTR testwork results – client supplied
Silica recovery	%	7.5	Average of preliminary DTR testwork results – client supplied
Concentrate production - desired	tpa	150,000	Nelson Bay River Magnetite Deposit Conceptual Mining Study,2007
Concentrate production - actual	tpa	151,190	Calculation

The mass balance is summarised in Table 6-3 below. Details of the mass balance can be found in Appendix G.

Table 6-3: Basic Mass Balance Summary for Alternative Magnetite Flowsheet

Stream Data	Feed	After Rougher Magnetic Separation	After Secondary Magnetic Separation	After Cleaner Magnetic Separation
Solid (tph)	53.3	32.2	22.6	19.2
Water (tph)	1.4	21.5	15.0	2.1
% Solids (w/w)	97.5	60	60.0	90
Fe %	40.9	54.1	61.8	68.2
SiO_2 %	22.6	18.7	10.7	4.7

6.4 Basic Process Control Points

A preliminary process control points flowsheet can be found in Figure 4. Details of the process control philosophy will be studied at the feasibility study stage.

The control points can be understood as follows:

- FT: Flow transmitter
- LT: Level transmitter
- DT: Density transmitter
- WT: Weightometer Transmitter

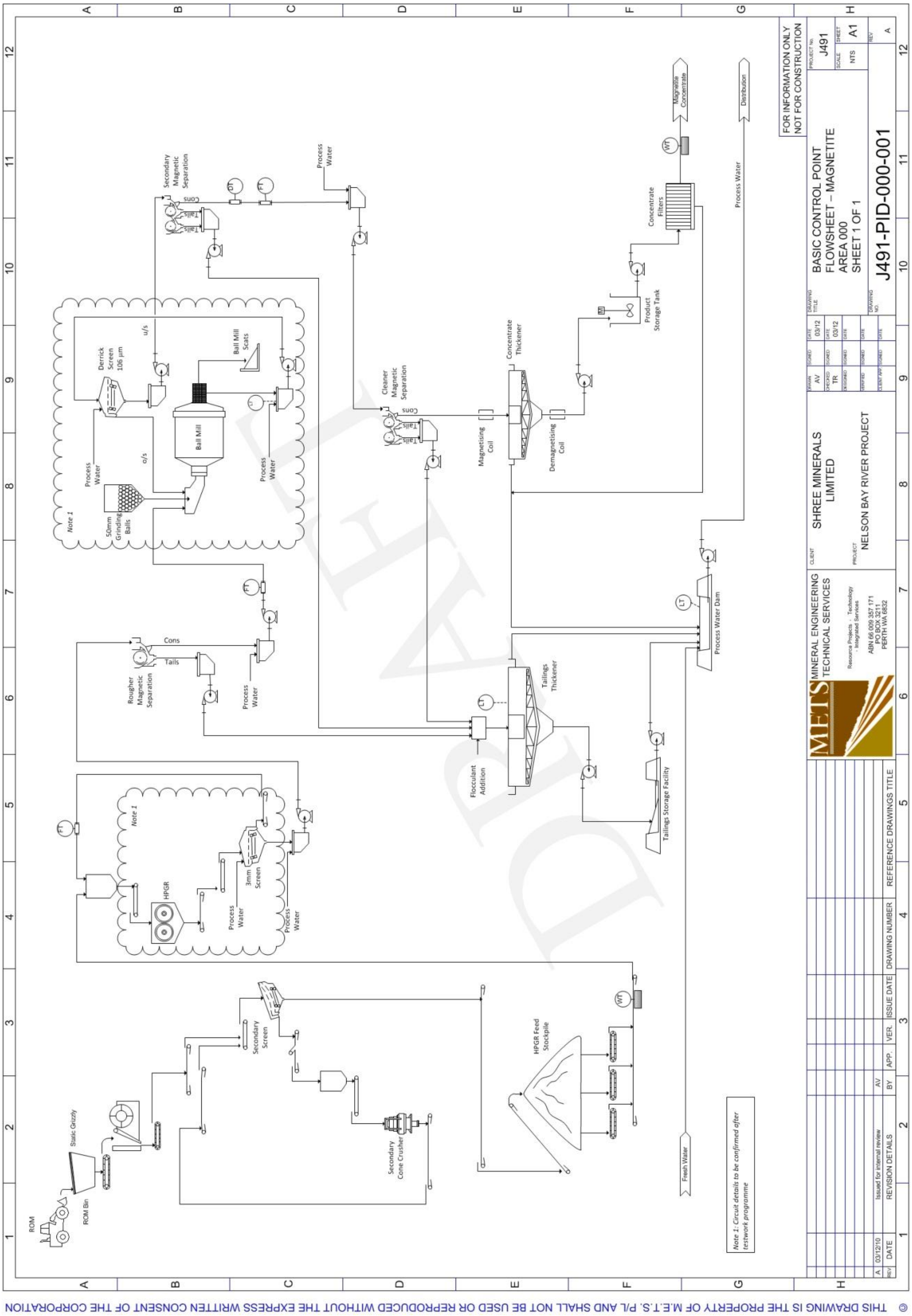


Figure 4: Basic Process Control Points Flowsheet

6.5 CAPEX and OPEX Review

6.5.1 CAPEX

The capital cost has been estimated for a plant using new equipment and also used equipment. The following capital costs have been identified.

- Cost for new equipment. $13,730,000
- Cost for used equipment. $10,350,000

The equipment CAPEX has been estimated based upon an annual magnetite plant feed rate of 400,000 tpa.

The following table identifies the equipment, cost and power required to produce the desired product.

Table 6-4 Capital Expenditure

Power					New Equipment		Used Eqpt (Second Hand)	
Kw			Specs	Unit	Unit Rate	Value	Unit Rate	Value
	HPGR	HPGR Feed Hopper	10 T steel	10	$ 7,500.00	$ 75,000.00		$ 75,000.00
25		Apron Feeder	10M long	1	$ 20,000.00	$ 20,000.00	5000	$ 5,000.00
15		HPGR Feed Conveyor	25 M Long	25	$ 2,000.00	$ 50,000.00	500	$ 12,500.00
		HPGR Feed Bin	2 t	2	$ 7,500.00	$ 15,000.00		$ 15,000.00
35		HPGR	150 tph feed	1	$ 1,500,000.00	$ 1,500,000.00		$ 1,500,000.00
20		HPGR Discharge Conveyor	30 m long	30	$ 2,000.00	$ 60,000.00	500	$ 15,000.00
10		Double Deck Vibrating Screen	1 unit	1	$ 25,000.00	$ 25,000.00	2500	$ 2,500.00
15		HPGR Recirculation Conveyor 1	25 m long	25	$ 2,000.00	$ 50,000.00	500	$ 12,500.00
15		HPGR Recirculation Conveyor 2	25 m long	25	$ 2,000.00	$ 50,000.00	500	$ 12,500.00
15		HPGR Product Conveyor	25 m long	25	$ 2,000.00	$ 50,000.00	500	$ 12,500.00
		HPGR Product Sump	5 t steel	5	$ 7,500.00	$ 37,500.00		$ 37,500.00
45		HPGR Product Slurry Pump	8x6 Warman	2	$ 25,000.00	$ 50,000.00	15000	$ 30,000.00
		Spillage Sump		1	$ 2,500.00	$ 2,500.00		$ 2,500.00
10		Spillage Sump Pump	65mm pump	1	$ 5,000.00	$ 5,000.00	1000	$ 1,000.00
						$ -		
75	Rougher Mag Sep	Rougher Mag Separator		1	$ 2,400,000.00	$ 2,400,000.00		$ 1,400,000.00
		Rougher Mag Sep Feed Hopper		0		$ -		
		Rougher Mag Sep Product Sump		0		$ -		
35		Rougher Mag Sep Product Pump		0		$ -		
		Rougher Mag Sep tails Sump		0		$ -		
35		Rougher Mag Sep Tails Pump		0		$ -		
						$ -		
	Grinding	Ball Mill Feed Hopper	2t steel	2	$ 7,500.00	$ 15,000.00		$ 15,000.00
50		Ball Charging System		1	$ 150,000.00	$ 150,000.00	50000	$ 50,000.00
		Cyclone Tower	25t steel	25	$ 7,500.00	$ 187,500.00		$ 187,500.00
		Cyclone system		1	$ 15,000.00	$ 15,000.00		$ 15,000.00
		Ball Mill Discharge Hopper	10 t steel	10	$ 7,500.00	$ 75,000.00		$ 75,000.00
75		Ball Mill Discharge Pump	10x12 Warman	2	$ 35,000.00	$ 70,000.00	20000	$ 40,000.00
500		Ball Mill		1	$ 500,000.00	$ 500,000.00		$ 500,000.00
	LIMS	LIMS Feed Hopper		0		$ -		
50		LIMS		0		$ -		
		LIMS Product Sump		0		$ -		
45		LIMS product pump		0		$ -		

	Cleaner Mag Sep	Cleaner Mag Sep feed Hopper	10t steel	10	$ 7,500.00	$ 75,000.00		$ 75,000.00
		Cleaner Concetrate Hopper	2 t steel	2	$ 7,500.00	$ 15,000.00		$ 15,000.00
35		Cleaner Conecntrate Pump	6x4 warman	2	$ 15,000.00	$ 30,000.00	8000	$ 16,000.00
		Cleaner Tails Hopper	2 t steel	2	$ 7,500.00	$ 15,000.00		$ 15,000.00
35		Cleaner Tails Pump	8x6 warman	2	$ 25,000.00	$ 50,000.00	15000	$ 30,000.00
75	Con Thickener	Con Thickener		1	$ 600,000.00	$ 600,000.00	350000	$ 350,000.00
50		Flocc plant		0		$ -		
45		Thickener U/F Pump		2	$ 25,000.00	$ 50,000.00	15000	$ 30,000.00
		Thickener O/F Sump	3 t steel	3	$ 7,500.00	$ 22,500.00		$ 22,500.00
45		Water recirulation Pump		2	$ 15,000.00	$ 30,000.00		$ 30,000.00
	Filter	Filter Feed system	2t steel	2	$ 7,500.00	$ 15,000.00		$ 15,000.00
75		Filter		1	$ 300,000.00	$ 300,000.00	150000	$ 150,000.00
		Filtrate Sump	2t steel	2	$ 7,500.00	$ 15,000.00		$ 15,000.00
35		Filtrate Pump		2	$ 15,000.00	$ 30,000.00		$ 30,000.00
15		Product Conveyor	20 M length	20	$ 2,000.00	$ 40,000.00	500	$ 10,000.00
25		Product Stacker	25 M length	25	$ 2,500.00	$ 62,500.00	500	$ 12,500.00
75	Tails Thickener	Tails Thickener		1	$ 750,000.00	$ 750,000.00	400000	$ 400,000.00
35		Flocc plant		0		$ -		
355		Tailing Pump	10x 12 warman	2	$ 35,000.00	$ 70,000.00	20000	$ 40,000.00
		Thickener O/F Sump	2t steel	2	$ 7,500.00	$ 15,000.00		$ 15,000.00
35		Water recirulation Pump		2	$ 15,000.00	$ 30,000.00		$ 30,000.00
110		Tails Dam Return Water Pump		2	$ 15,000.00	$ 30,000.00		$ 30,000.00
	PWD	PWD		1	$ 150,000.00	$ 150,000.00		$ 150,000.00
110		PWD Pumps		2	$ 30,000.00	$ 60,000.00	15000	$ 30,000.00
		PWD Ring Header		1	$ 35,000.00	$ 35,000.00		$ 35,000.00
		Communications				$ 200,000.00		$ 200,000.00
		Site Preparation				$ 875,000.00		$ 875,000.00
		Offices and Buildings				$ 325,000.00		$ 325,000.00
		Site Vehicles				$ 175,000.00		$ 175,000.00
2225						$ 9,467,500.00		$ 7,137,000.00
		Engineering	10%			$ 946,750.00		$ 713,700.00
		Electrics	15%			$ 1,420,125.00		$ 1,070,550.00
		Instrumentation	10%			$ 946,750.00		$ 713,700.00
		Contingency	10%			$ 946,750.00		$ 713,700.00
						$ 13,727,875.00		$ 10,348,650.00
		Capital Cost				$ 13,727,875.00		$ 10,348,650.00
						Average		
						$ 12,038,263		

CAPEX is used for calculating operating maintenance costs and the average of new and used equipment has been used.

6.5.2 Operating cost

The overall operating costs have been estimated as $3,600,000 per year, not including mining and administration costs. This equates to $8-93/ tonne of ore treated.

Some of the specific costs are

Table 6-5 Manpower

Manpower			
	Number	$ Rate	$ Cost
Skilled	8	95,000	760,000
UnSkilled	4	65,000	260,000
Supervisor	1	140,000	140,000
Engr	1	140,000	140,000
TOTAL	**14**		**1,300,000**

Table 6-6 Power

Power	
kWh	2225
c/kWh	0.19
Op. hrs/ year	3000
$ per year	**1,268,250**

Table 6-7 Consumables & Maintenance

Consumables & Maintenance			
Item	Rate	$ Base	$ Cost
Consumables			100,000
Maintenance	0.075	12,038,263	902,870

Manpower, maintenance and power are the major operating contributors and account for most of the expenses. The overall unit rate of $8-93 per tonne can be dissected into the following components

Table 6-8 Operating Cost Unit Consumption

Item	Annual Cost $	Unit Rate c/tonne
Manpower	1,300,000	3.25
Power	1,268,250	3.17
Consumables	100,000	0.25
Maintenance	902,870	2.26
TOTAL	**3,571,120**	**8.93**

7. CONCLUSIONS

Ore characterisation testwork indicated that the ore was typical of its type and would not cause major issues by being processed in a typical crushing and grinding circuit.

A review of the magnetite processing conceptual flow diagram provided by the client highlighted a few issues and strongly suggested that a HPGR would be an appropriate method of crushing if the ore was amenable to it.

A single HPGR test on a truncated feed gave sufficient encouragement to recommend that a more comprehensive trial be conducted in order to obtain design parameters.

APPENDIX A – HEMATITE TESTWORK SAMPLE

Hole	From	To	Sample #	Type	weight
					(kg)
NBR020	7.65	8.40	366419	½	2.00
	8.40	9.40	366420	½	2.53
	9.40	11.00	366421	½	1.84
	11.00	12.10	366422	½	1.83
	12.60	13.60	366423	½	2.87
	13.60	14.60	366424	½	1.55
	14.60	15.60	366425	½	2.63
NBR019	14.70	15.70	366402	½	4.04
	15.70	16.70	366403	½	2.92
	16.70	17.70	366404	½	4.71
	17.70	18.70	366405	½	4.42
	18.70	19.70	366406	½	4.12
	19.70	20.70	366407	½	4.59
	20.70	21.70	366408	½	4.25
	21.70	22.70	366409	½	3.53
	22.70	23.70	366410	½	4.02
	23.70	24.70	366411	½	4.86
NBR022	31.15	32.15	366465	½	3.97
	32.15	33.15	366466	½	3.61
	33.15	34.15	366467	½	3.58
	34.15	35.15	366468	½	3.75
	35.15	36.15	366469	½	3.22
	36.15	37.10	366470	½	3.30
	37.10	39.70	366471	½	1.19
	39.70	42.70	366472	½	1.33

Hole	From	To	Sample #	Type	weight
					(kg)
NBR020	7.65	8.40	366419	½	2.00
	8.40	9.40	366420	½	2.53
	9.40	11.00	366421	½	1.84
	11.00	12.10	366422	½	1.83
	12.60	13.60	366423	½	2.87
	13.60	14.60	366424	½	1.55
	14.60	15.60	366425	½	2.63
NBR019	14.70	15.70	366402	½	4.04
	15.70	16.70	366403	½	2.92
	16.70	17.70	366404	½	4.71
	17.70	18.70	366405	½	4.42
	18.70	19.70	366406	½	4.12
	19.70	20.70	366407	½	4.59
	20.70	21.70	366408	½	4.25
	21.70	22.70	366409	½	3.53
	22.70	23.70	366410	½	4.02
	23.70	24.70	366411	½	4.86
NBR022	31.15	32.15	366465	½	3.97
	32.15	33.15	366466	½	3.61
	33.15	34.15	366467	½	3.58
	34.15	35.15	366468	½	3.75
	35.15	36.15	366469	½	3.22
	36.15	37.10	366470	½	3.30
	37.10	39.70	366471	½	1.19
	39.70	42.70	366472	½	1.33
NBR006	10.00	11.00	367001	¼	1.07
	11.00	12.00	367002	¼	1.21
	12.00	13.00	367003	¼	1.14
	13.00	14.00	367004	¼	1.49
	14.00	15.00	367005	¼	1.82

	15.00	16.00	367006	¼	2.17
	16.00	17.00	367007	¼	2.33
	17.00	18.00	367008	¼	1.66
NBR009	35.60	38.50	367009	¼ 0.9m	0.97
	38.50	40.40	367010	¼ 1.1m	1.05
	40.40	47.50	367011	¼ 0.5m	0.55
NBR010	5.50	7.20	367012	¼ 0.6m	0.53
	7.20	8.50	367013	¼ 1.0m	0.97
	8.50	9.50	367014	¼ 1.0m	0.79
	9.50	10.50	367015	¼ 1.0m	0.77
	10.50	12.00	367016	¼ 0.75m	0.88
	12.00	13.00	367017	¼ 1.0m	1.10
	13.00	14.50	367018	¼ 0.9m	0.85
	14.50	15.00	367019	¼ 0.5m	0.39
NBR012	5.50	8.50	367020	¼ 0.8m	0.57
	8.50	9.40	367021	¼ 0.9m	0.91
	9.40	11.50	367022	¼ 0.4m	0.38
	11.50	13.00	367023	¼ 1.5m	1.40

Hole	From	To	Sample #	Type	weight
					(kg)
NBR013	15.00	16.00	367024	¼ 1.0m	1.08
	16.00	17.00	367025	¼ 0.8m	0.69
	17.00	18.00	367026	¼ 0.8m	0.82
	18.00	19.00	367027	¼ 1.0m	0.91
	19.00	20.00	367028	¼ 1.0m	0.90
	20.00	21.00	367029	¼ 0.9m	1.08
	21.00	22.00	367030	¼ 0.8m	0.83
	22.00	23.00	367031	¼ 0.9m	0.92
	23.00	24.00	367032	¼ 1.0m	1.24
	24.00	25.00	367033	¼ 1.0m	0.98
	25.00	26.00	367034	¼ 0.4m	0.34
NBR014	11.00	11.50	367035	¼ 0.5m	0.50
	11.50	13.00	367036	¼ 0.9m	0.79
	13.00	13.90	367037	¼ 0.9m	0.77
	13.90	15.80	367038	¼ 0.7m	0.59
	15.80	17.10	367039	¼ 1.1m	1.16
	17.10	19.00	367040	¼ 0.5m	0.60
	19.00	20.50	367041	¼ 0.5m	0.51
	20.50	22.20	367042	¼ 0.3m	0.24
NBR016	20.50	22.00	367043	¼ 0.6m	0.42
	22.00	23.50	367044	¼ 1.1m	1.21
	23.50	26.50	367045	¼ 0.5m	0.51
	26.50	29.50	367046	¼ 1.2m	1.07
	29.50	31.00	367047	¼ 1.5m	1.39

APPENDIX B – UCS TESTWORK RESULTS

AMMTEC LTD

UNCONFINED COMPRESSIVE STRENGTH DETERMINATION

PROJECT	A13122
CLIENT	SHREE MINERALS
ORE TYPE	Hematite
SPECIMENT	Half HQ Core (366403)
DATE	Oct-10

Instrument : Martest [3000kN]

Rate Of Load Application = 10 kN / minute

Sample Details :

Sample type :	Half HQ Core
Diameter (mm) :	61.2
Height (mm) :	122.9
Moisture (%) :	0.0

* : FULL PQ CORE USED

Test Results :

Failure At :	47.242 (kN)
Failure Mode :	SHEAR
U.C.S. :	32.2 (mPa)

Typical Compressive Strengths :

Rock Type	U.C.S. (mPa) Dry	U.C.S. (mPa) Saturated
Basalt	106-168	85-223
Pyroclastic Basalt	143	64
Dolomite	114	95
Granite	98-119	104-114
Pyrophyritic Granite	86	95
Tourmaline Granite	158	107
Granulite	151	82
Gneiss	96-155	91-174
Granitic Gneiss	106-159	72-135
Limestone	73-85	48-98
Quartzite	256	206
Sandstone	81	73

Descriptive Strength Terms :

U.C.S. (mPa)	Strength
< 6	Very Weak
6-20	Weak
20-60	Med' Strong
60-200	Strong
> 200	Very Strong

APPENDIX C – CWi

AMMTEC LTD

BOND IMPACT CRUSHABILITY TEST RESULTS

Sample Identity	:	LOW GRADE CWi - LG
Size (mm)	:	-75+51mm
Job Number	:	A13122
client	:	SHREE MINERALS
Date	:	November 2010

TEST RESULTS

Impact Work Index (Average) :	9.5	kWh/tonne
	8.6	kWh/short ton
Sample SG :	3.51	

Specimen Number - ID	Thickness (mm)	Impact Energy (joules)	Work Index (kWh/tonne)
1 (366419)	29.4	27.1	14.1
2 (366420)	29.8	16.3	8.3
3 (366421)	29.4	10.8	5.6
4 (366423)	29.4	21.7	11.3
5 (366424)	30.3	16.3	8.2

Maximum Work Index	14.1
Minimum Work Index	5.6
Standard Deviation	3.2

AMMTEC Ltd.

APPENDIX D – Ai TESTWORK RESULTS

BOND ABRASION INDEX DETERMINATION

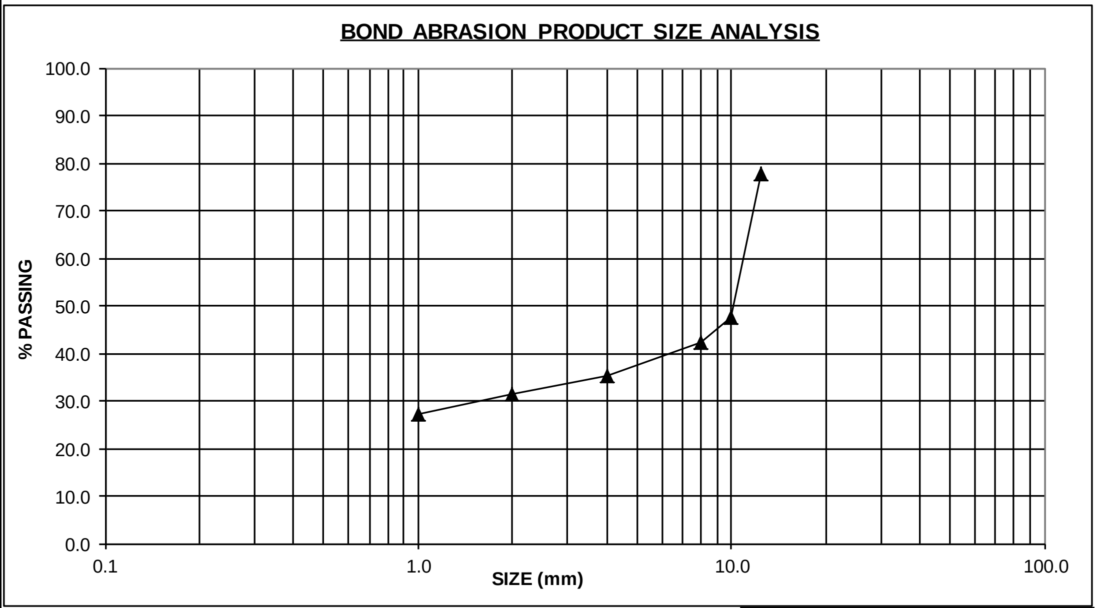
SAMPLE IDENTITY	HG
JOB NUMBER	A13122
CLIENT	SHREE MINERALS
DATE	Nov-10

SIZE ANALYSIS : ABRASION INDEX PRODUCT

Operation	Size (mm)	Weight (g)	Weight (%)	Weight %<
Screening	12.5	353.3	22.2	77.8
	10.0	484.1	30.4	47.4
	8.00	80.4	5.0	42.4
	4.00	113.2	7.1	35.3
	2.00	63.9	4.0	31.3
	1.00	63.4	4.0	27.3
	-1.00	434.4	27.3	
Total		1592.7	100.00	

PADDLE WEIGHT BEFORE TEST (g) : 88.9126
PADDLE WEIGHT AFTER TEST (g) : 88.7280

BOND ABRASION INDEX (Ai) : *0.1846*



AMMTEC Ltd.

BOND ABRASION INDEX DETERMINATION

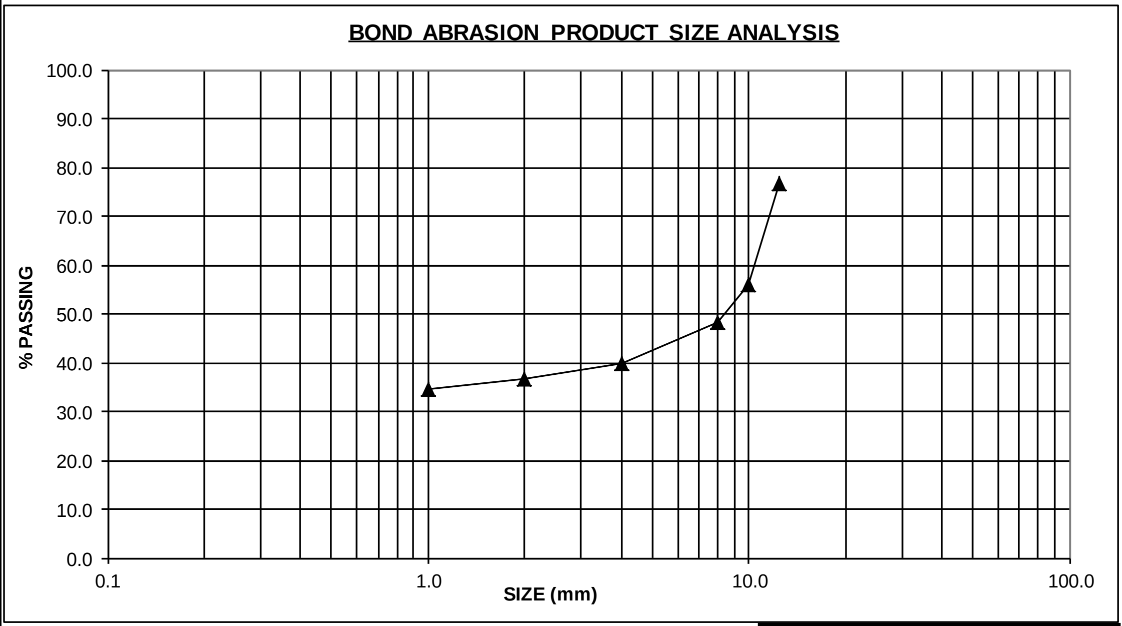
SAMPLE IDENTITY	LG
JOB NUMBER	A13122
CLIENT	SHREE MINERALS
DATE	Nov-10

SIZE ANALYSIS : ABRASION INDEX PRODUCT

Operation	Size (mm)	Weight (g)	Weight (%)	Weight %<
Screening	12.5	372.1	23.3	76.7
	10.0	328.5	20.6	56.1
	8.00	127.2	8.0	48.1
	4.00	129.6	8.1	40.0
	2.00	50.0	3.1	36.8
	1.00	35.5	2.2	34.6
	-1.00	551.5	34.6	
Total		1594.4	100.00	

PADDLE WEIGHT BEFORE TEST (g) : 88.5633
PADDLE WEIGHT AFTER TEST (g) : 88.4010

BOND ABRASION INDEX (Ai) : *0.1623*



APPENDIX E – DROP TOWER TEST

SAMPLE	SIZING			% Lump	% Fines	Total
	+6.3mm	**-6.3mm**	**Total**	**+6.3mm**	**-6.3mm**	**Total**
Composite - HG	(kg)	(kg)	(kg)			
Crushed on CSS 31mm	74.80	14.56	89.36	83.71	16.29	100.00
After 5 Drops (+6.3)	60.20	13.96	74.16	81.18	18.82	100.00
Total for Testwork	60.20	28.52	88.72	67.85	32.15	100.00

Drop Test Result HG Composite

Comp Lump

Sample No.	Screen Size (mm)	Screen Weight (kg)	Weight Percent	Cum. Passing
LUMP	-31+25	1.19	24.84	100.00
	-25+20	1.13	23.59	75.16
	-20+15	0.93	19.42	51.57
	-15+10	0.87	18.16	32.15
	-10+8	0.31	6.47	13.99
	-1.7	0.36	7.52	7.52
	TOTAL ALL	4.79	100.0%	

Comp Fines

Sample No.	Screen Size (mm)	Screen Weight (g)	Weight Percent	Cum. Passing
FINES	-6.3+3.35	524.30	26.15	100.00
	-3.35+1.18	504.30	25.15	73.85
	-1.18+0.60	230.70	11.51	48.70
	-0.60+0.30	215.10	10.73	37.19
	-0.30+0.15	193.00	9.63	26.46
	-0.15+0.090	115.70	5.77	16.83
	-0.090+0.075	74.80	3.73	11.06
	-0.075	147.00	7.33	7.33
	Total	2004.90	100.00	

APPENDIX F – HPGR REPORT

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

Koeppern Machinery Australia Pty Ltd · 73 Pavers Circle · Malaga WA 6090

Mr Jeff West
Mineral Engineering Technical Services PTY LTD
Level 6, 524 Hay St,
Perth, 6000

CC: Lee Hung – Ammtec.

Our reference	Telephone No.	Facsimile No.	Date
KMA1041jdQtw	08 9248 4170	08 9248 4176	21st Dec 2010

High Pressure Comminution

Test Work Report

for

Processing of magnetite ore
For METS

Shree minerals Project

This report is confidential and shall not be distributed to third parties without Köppern's consent.

Koeppern Machinery Australia Pty Ltd (ABN 26 072 782 891)
73 Pavers Circle, Malaga WA 6090
P.O. Box 2465, Malaga WA 6944

Telephone: (08) 9248 4170
Facsimile: (08) 9248 4176
E-mail: info@koeppern.com.au

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

Contents

List of figures

List of tables

List of appendices

Koeppern Machinery Australia Pty Ltd (ABN **26 072 782 891**)
73 Pavers Circle, Malaga, WA 6090
P.O. Box 2465, Malaga, WA 6944
Telephone: (08) 9248 4170
Facsimile: (08) 9248 4176
E-mail: info@koeppern.com.au

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

1. Executive summary

The purpose of the test work program was to ascertain the applicability of high pressure roller grinding to the magnetite ore supplied by METS for the Shree minerals project.

The test showed promising results although the applicability of the results is a long way from real world application due to the truncated condition of the feed material.

The main problems with the provided sizing process data can be summarised as follows:

- The sample size was significantly smaller than the recommended minimum quantity of material.
- Truncated feed conditions have a considerable negative effect on HPGR performance.
- The recorded product allowed an assessment of comminution performance but not process parameter modelling data.

Further tests are required to offer sizing and process performance guarantees.

For this confirmatory test work program only a very limited amount of material was available hence the decision to conduct only a single pass test at process parameters similar to those used in ores of similar characteristics as experienced by Koeppern.

The main observations from this program are:

- Significant size reduction through HPGR comminution were measured
- A specific pressing force of 3,000 kN/m^2 were tested only – this pressing force proved reasonably efficient but not necessarily optimal
- Specific energy consumption was within expected range, albeit on the higher side, for the applied pressing forces
- Further testing is justified

This test work program conducted on the ore sample as provided by METS demonstrated that the ore responds well to the high pressure comminution process. We strongly recommend that a full test work program is conducted for this project.

Koeppern Machinery Australia Pty Ltd (ABN 26 072 782 891)
73 Pavers Circle, Malaga, WA 6090
P.O. Box 2465, Malaga, WA 6944
Telephone: (08) 9248 4170
Facsimile: (08) 9248 4176
E-mail: info@koeppern.com.au

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

2. Test equipment

All experiments were carried out on the HPGR pilot plant designed by Köppern and located at Ammtec in Balcatta, Perth. The press is fitted with Köppern's proprietary wear protection Hexadur® WTII, specifically designed for comminution of highly abrasive minerals. Table 1 shows the specifications of the pilot plant.

Roller Diameter:	1000 mm.
Roller width:	250 mm.
Press drive:	Planetary gear box
Feed system:	Gravity
Wear surface:	Hexadur® WTII
Installed Power:	264kW
Maximum pressing force:	1600kN
Maximum specific pressing force:	8.5N/mm^2
Variable speed drive:	up to 21 rpm (1.1 m/s)

Table 1: Pilot plant HPGR technical data

Figure 1: Main view of the HPGR pilot plant and Hexadur® wear surface.

Experimental data is recorded every 100ms. The computer system measures: time; roller gap (left and right); pressing force (left and right); fixed and floating shaft torques; power consumption. This data allows for in-depth process analysis and sizing of HPGR presses for industrial applications.

Koeppern Machinery Australia Pty Ltd (ABN 26 072 782 891)
73 Pavers Circle, Malaga, WA 6090
P.O. Box 2465, Malaga, WA 6944
Telephone: (08) 9248 4170
Facsimile: (08) 9248 4176
E-mail: info@koeppern.com.au

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

3. Definitions

Process specific throughput constant (m-dot)

The press throughput W [t/h] is a function of, roller diameter D[m], roller width L [m] and roller peripheral speed v [m/s] and the specific throughput constant (m-dot). The value is calculated from:

$$m - dot = \frac{W}{DLv} \qquad [ts/hm^3]$$

Where:	W [t/h]	–	throughput rate
	D [m]	–	roller diameter
	L [m]	–	roller width
	v [m/s]	–	roller peripheral speed

The specific throughput constant m-dot is used to calculate the throughput of HPGRs which differ in size. For a given feed material, m-dot represents the throughput [t/h] of an HPGR fitted with rollers 1 m in diameter, 1 m width and revolving at 1 m/s peripheral speed.

Specific pressing force (F_{sp})

Specific pressing force represents the total pressing force applied on the floating roller by the HPGR hydraulic system per unit surface area of the roller cross section.

$$F_{sp} = \frac{F}{LD} \qquad [kN/m^2]$$

Where: F [kN] – Total pressing (grinding) force

Specific pressing force is used for process performance comparison of HPGRs which differ in size.

Net specific energy consumption (E_{sp})

Net specific energy describes the energy consumed by the grinding process for each tonne of feed/product material. It is determined by the following:

$$E_{SPnet} = \frac{P_t - P_i}{W_{sp}} \qquad [kWh/t]$$

Where:	P_t [kW]	–	total power draw (fixed and floating roller combined)
	P_i [kW]	–	power draw (fixed and floating roll combined) in idle conditions
	W_{sp} [t/h]	–	press throughput

Net specific power consumption is used to determine the required main motor size for an industrial application.

5

Koeppern Machinery Australia Pty Ltd (ABN 26 072 782 891)
73 Pavers Circle, Malaga, WA 6090
P.O. Box 2465, Malaga, WA 6944
Telephone: (08) 9248 4170
Facsimile: (08) 9248 4176
E-mail: info@koeppern.com.au

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

4. HPGR Pilot plant test work

HPGR Feed material preparation and description of test samples

One drum of magnetite was supplied and the material was tested as supplied.

A representative sample was split from the batch for determination of feed PSD, bulk density and moisture content (adjusted after crushing and homogenisation), the results of feed material tests are summarized in the Table 2 below.

Sample number	Sample type	Moisture content	Bulk density	F_{80}	F_{50}
		[%]	t/m³	[mm]	[mm]
SIG001	Magnetite	As supplied	1.66	30.61	27.81

Table 2: Feed parameters

Test work program

The following test program was agreed with the client prior to commencement:

Description	Test number	Sample type	Moisture	Static gap	Roller speed		Specific pressing force
				X_0	v	v	F_{SP}
			[%]	[mm]	[rpm]	[m/s]	[N/mm²]
Evaluation of comminution	SIG001	Magnetite	As supplied	12.1	19.2	1.0	3.0

Table 3: Process set point parameters

HPGR products were split at the product conveyor using a diverter gate. Approximately equal amounts of drive and non-drive edge product were collected. The diverter gate was adjusted to collect approximately 27% of total edge product and 73% of centre product.

Koeppern Machinery Australia Pty Ltd (ABN 26 072 782 891)
73 Pavers Circle, Malaga, WA 6090
P.O. Box 2465, Malaga, WA 6944
Telephone: (08) 9248 4170
Facsimile: (08) 9248 4176
E-mail: info@koeppern.com.au

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

HPGR Test work results

A summary of main test results are presented in table 4.

Test number	Sample type	Specific pressing force	Specific throughput constant	Net specific energy consumption	Particle size		Percentage passing	
		F_{SP}	M-dot	$E_{SP\ net}$	P80	P50	-8.00 mm	-1.00 mm
		[N/mm^2]	[ts/hm^3]	[kWh/t]	[mm]		[%]	
SIG001	Magnetite	3	184.78	2.29	15.87	5.97	56.2	24.1

Table 4: Summary of test results

The values included in the summary are considered to be critical indicators of grinding performance. Full results are tabulated in appendix A.

4.1.1 Comminution effect – product PSD

The high pressure comminution process produced reasonable product fineness and significant size reduction. Comminution performance is represented by product fineness P80 and P50 and is presented in table 5 below. Complete results of particle size distribution analysis are presented in Appendix A.

Feed: 80% passing size	P_{80}	[mm]	30.61
Feed: 50% passing size	P_{50}	[mm]	27.81
Centre: 80% passing size	P_{80}	[mm]	14.62
Centre: 50% passing size	P_{50}	[mm]	5.14
Edge: 80% passing size	P_{80}	[mm]	18.41
Edge: 50% passing size	P_{50}	[mm]	9.41
Scale-up: 80% passing size	P_{80}	[mm]	15.87
Scale-up: 50% passing size	P_{50}	[mm]	5.97
Reduction ratio F80/P80			1.93
Reduction ratio F50/P50			4.66
Combined product percentage passing 3 mm		[%]	56.20
Combined product percentage passing 1 mm		[%]	24.10

Table 5: Particle sizing data

Koeppern Machinery Australia Pty Ltd (ABN 26 072 782 891)
73 Pavers Circle, Malaga, WA 6090
P.O. Box 2465, Malaga, WA 6944
Telephone: (08) 9248 4170
Facsimile: (08) 9248 4176
E-mail: info@koeppern.com.au

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

As expected the material did show comminution though the performance was a long way from ideal. The main factor in the poor comminution performance was the truncated feed. Truncated feed makes the crushing performance of the HPGRs drop off sharply. Had fines been present in the feed material greatly improved comminution at greater efficiencies would have been achieved.

As only one data point was obtained for this sample trend lines and thus performance characteristics cannot be established and thus optimal running conditions cannot be determined.

4.1.2 Specific throughput

The specific throughput constant (m-dot) has been calculated from experimental data. The specific throughput for IRD is 184.78 ts/hm^3. This value is very low for the material type.

4.1.3 Energy consumption

Net energy consumption was calculated from recorded process data and represents actual energy input during stable press operation. The specific energy of 2.29kW/h is higher than expected for the conditions and material tested.

5. Discussion of test work results

The limited number of tests that were carried out on the supplied material provided an indication that the ore is amenable to the high pressure comminution process. In Koeppern's opinion had full feed been used instead of truncated feed the results would have been greatly improved. The feed material did indicate that it is amenable to high pressure comminution. Further investigation would show just how amenable but at this stage the results obtained are not reliable enough to justify even guessing at possible performance characteristics.

5.1 Comminution effect:

The main factor in the poor comminution performance was the truncated feed. Truncated feed makes the crushing performance of the HPGRs drop off sharply. Had fines been present in the feed material greatly improved comminution at greater efficiencies would have been achieved.

This can be viewed as a starting point for major improvements. Further testing would allow optimal conditions to be determined.

Koeppern Machinery Australia Pty Ltd (ABN 26 072 782 891)
73 Pavers Circle, Malaga, WA 6090
P.O. Box 2465, Malaga, WA 6944
Telephone: (08) 9248 4170
Facsimile: (08) 9248 4176
E-mail: info@koeppern.com.au

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

5.2 Energy expenditure

The energy expenditure recorded during the run falls in the top range for the material type. With full feed conditions and proper operating parameters better comminution efficiency should be achieved.

5.3 Press throughput

The throughput for this ore falls in the lower end of the range for this type of ore and when taken together with the PSDs and the fact that the feed was truncated is a good indication that high pressure comminution has good potential for this ore. No pre-screening and a larger sample size would greatly improve the throughput.

6. Final comments and recommendations

The limited number of tests that were conducted is inadequate for press sizing and defining of process guarantees. We strongly recommend conducting a complete test work program for the project using representative material types.

The test work program for final sizing of the HPGR for the project should include following segments:

- Assess relationship between specific pressing force and main process parameters
- Assess the influence of roller speed on process performance
- Assess the influence of feed material moisture on process performance
- Assess the impact of feed material top size on comminution performance
- Carry out test runs with selected ore blends
- Carry out closed circuit simulation
- Carry out progressive grind tests

Koeppern Machinery Australia Pty Ltd (ABN 26 072 782 891)
73 Pavers Circle, Malaga, WA 6090
P.O. Box 2465, Malaga, WA 6944
Telephone: (08) 9248 4170
Facsimile: (08) 9248 4176
E-mail: info@koeppern.com.au

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

We understand that obtaining a sample of the size required for further testing has significant difficulties; however we feel that for this ore the additional test work is justified. If a rough indication of sizing is required please contact us. It is suggested that a meeting is arranged to discuss the possibilities that HPGR could offer for the tested ore. Please don't hesitate to contact us should you have any queries relating to the above report.

Koeppern Machinery Australia.

Jason Dury
- Project Engineer -

Steve Sinclair
- Commercial manager -

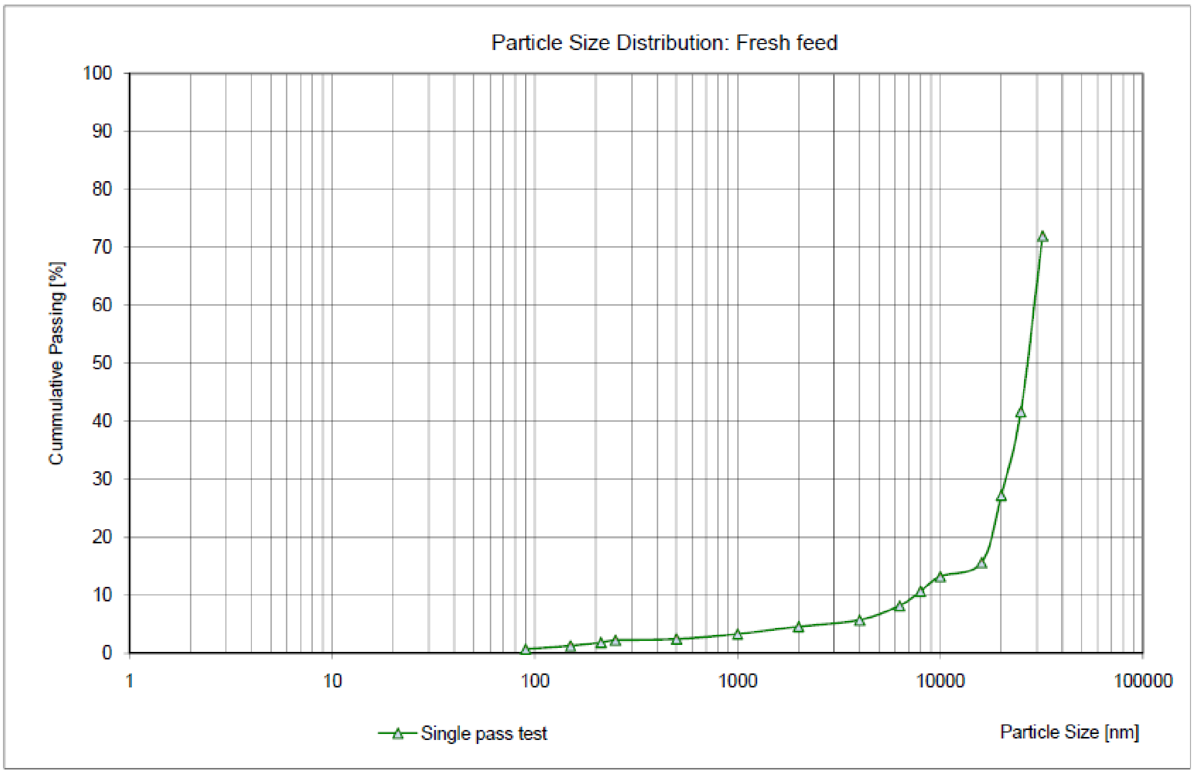
Koeppern Machinery Australia Pty Ltd (ABN **26 072 782 891**)
73 Pavers Circle, Malaga, WA 6090
P.O. Box 2465, Malaga, WA 6944
Telephone: (08) 9248 4170
Facsimile: (08) 9248 4176
E-mail: info@koeppern.com.au

KOEPPERN MACHINERY AUSTRALIA
ABN 26 072 782 891

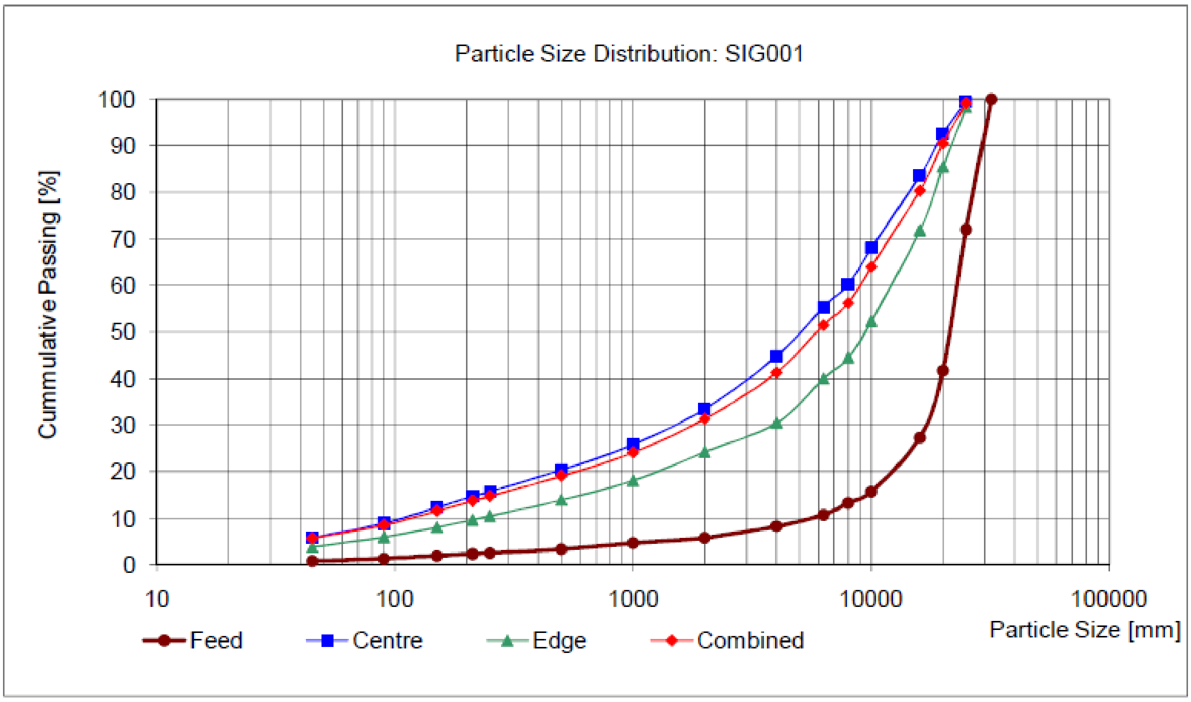
Appendix A

Shree Feed Material		Single pass test	
Screen Size	Screen Weight	Weight Percentage	Cumulative Passing
[µm]	[g]	[%]	[%]
32000	0	0.00	100.00
25000.00	4190	28.03	71.97
20000.00	4530	30.30	41.67
16000.00	2160	14.45	27.22
10000.00	1730	11.57	15.65
8000.00	360	2.41	13.24
6300.00	380	2.54	10.70
4000.00	370	2.47	8.23
2000.00	370	2.47	5.75
1000.00	170	1.14	4.62
500.00	193.8	1.30	3.32
250.00	126.2	0.84	2.47
212.00	30.4	0.20	2.27
150.00	60.9	0.41	1.86
90.00	85.7	0.57	1.29
45.00	81.9	0.55	0.74
-45.00	111.1	0.74	
Total	14950.0	100.00	

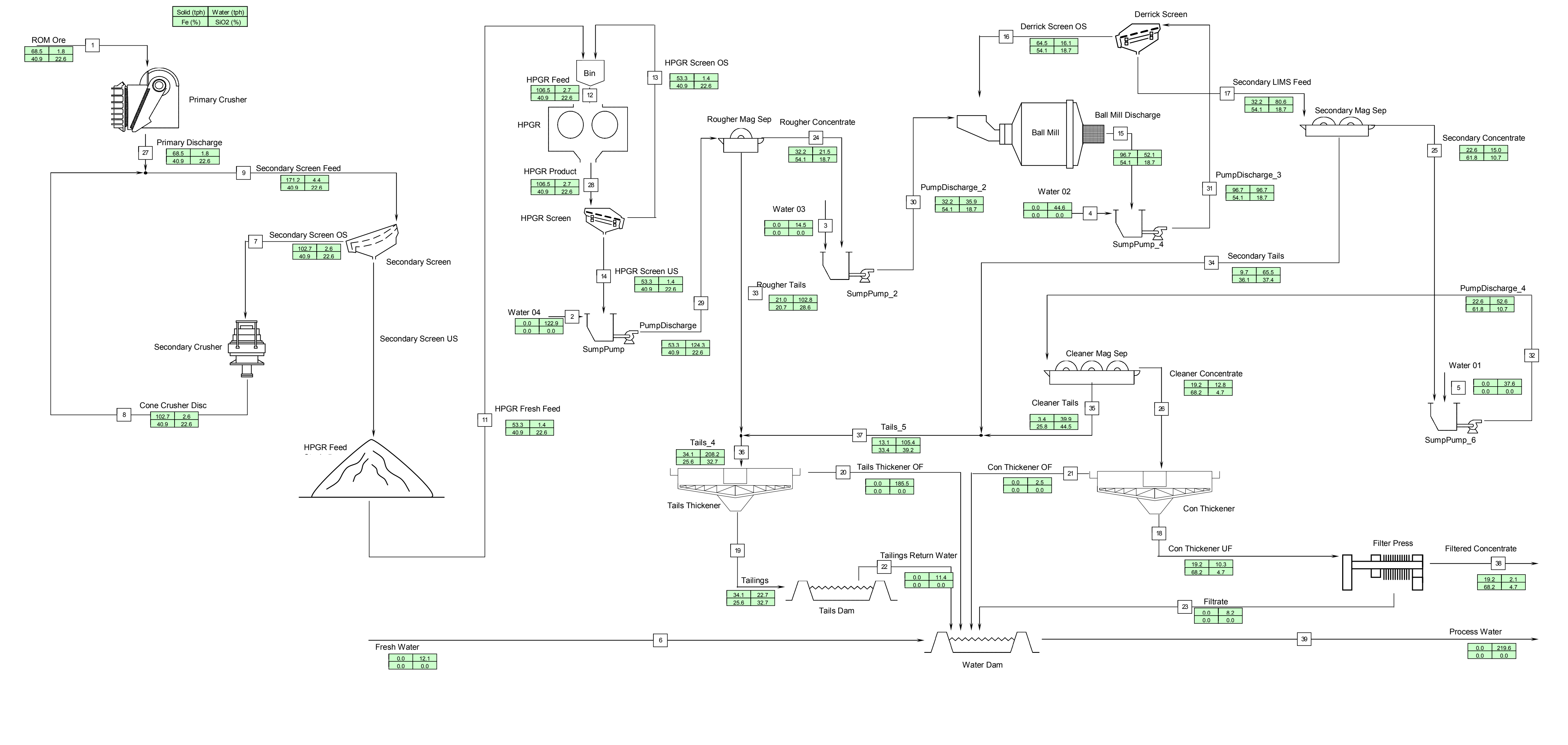
Calculated F_{80}	[mm]	30.61
Calculated F_{50}	[mm]	27.81
Passing 3.15 mm	[%]	7.18
Passing 1 mm	[%]	4.62



SIG001	Centre			Edge			Centre + 1/3 Edge Combined				
	Total Weight	% of total Product Sample Weight		Total Weight	% of total Product Sample Weight		Total Weight	% of total Feed Sample Weight		Waste	Total Weight
	[kg]	%		[kg]	%		[kg]	%		[kg]	[kg]
	92	73.5		33.2	26.5		125.2	57.64		92	217.2
Particle Size	Screen Weight	Weight Percentage	Cumulative Passing	Screen Weight	Weight Percentage	Cumulative Passing	Screen Weight	Weight Percentage	Cumulative Passing		
[µm]	[g]	[%]	[%]	[g]	[%]	[%]	[g]	[%]	[%]		
25000	60.0	0.60	99.40	170.0	1.78	98.22	119.9	0.89	99.11		
20000	670.0	6.75	92.64	1390.0	14.57	85.43	1161.1	8.63	90.48		
16000	900.0	9.07	83.57	1300.0	13.63	71.80	1361.5	10.12	80.36		
10000	1540.0	15.52	68.04	1860.0	19.50	52.31	2202.3	16.37	63.99		
8000	780.0	7.86	60.18	750.0	7.86	44.44	1048.3	7.79	56.20		
6300	480.0	4.84	55.34	430.0	4.51	39.94	634.1	4.71	51.48		
4000	1050.0	10.58	44.76	910.0	9.54	30.40	1376.4	10.23	41.25		
2000	1120.0	11.29	33.47	590.0	6.18	24.21	1335.2	9.92	31.33		
1000	760.0	7.66	25.81	590.0	6.18	18.03	972.3	7.23	24.10		
500	539.0	5.43	20.37	394.3	4.13	13.90	681.1	5.06	19.04		
250	466.0	4.70	15.68	330.8	3.47	10.43	585.4	4.35	14.69		
212	101.4	1.02	14.65	76.9	0.81	9.62	129.1	0.96	13.73		
150	234.4	2.36	12.29	148.0	1.55	8.07	288.0	2.14	11.58		
90	333.4	3.36	8.93	208.3	2.18	5.89	408.9	3.04	8.55		
45	316.7	3.19	5.74	200.7	2.10	3.78	389.4	2.89	5.65		
-45	629.1	6.34		360.9	3.78		760.2	5.65			
	9920.0	100.00		9540.0	100.0		13453.2	99.1			
	1.0081			1.04822							
	Calculated P80	[mm]	14.62			18.41			15.87		
	Calculated P50	[mm]	5.14			9.41			5.97		
	(-8mm)								56.20		
	(-1mm)								24.10		


Particle Size Distribution: SIG001
Cummulative Passing [%]
100
90
80
70
60
50
40
30
20
10
0
10
100
1000
10000
100000
Particle Size [mm]
Feed
Centre
Edge
Combined

APPENDIX G – MASS BALANCE PFD



STREAM ID:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
STREAM DATA																				
Solid (tph)	68.5	0.0	0.0	0.0	0.0	0.0	102.7	102.7	171.2	68.5	53.3	106.5	53.3	53.3	96.7	64.5	32.2	19.2	34.1	0.0
Water (tph)	1.8	122.9	14.5	44.6	37.6	12.1	2.6	2.6	4.4	1.8	1.4	2.7	1.4	1.4	52.1	16.1	80.6	10.3	22.7	185.5
% Solids (w/w)	97.5	0.0	0.0	0.0	0.0	0.0	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	65.0	80.0	28.6	65.0	60.0	0.0
Fe %	40.9	0.0	0.0	0.0	0.0	0.0	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	54.1	54.1	54.1	68.2	25.6	0.0
SiO2 %	22.6	0.0	0.0	0.0	0.0	0.0	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	18.7	18.7	18.7	4.7	32.7	0.0
STREAM NAME	ROM Ore	Water 04	Water 03	Water 02	Water 01	Fresh Water	Secondary Screen OS	Cone Crusher Disc	Secondary Screen Feed	HPGR Stockpile Feed	HPGR Fresh Feed	HPGR Feed	HPGR Screen OS	HPGR Screen US	Ball Mill Discharge	Derrick Screen OS	Secondary LIMS Feed	Con Thickener UF	Tailings	Tails Thickener OF

STREAM ID:	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
STREAM DATA																			
Solid (tph)	0.0	0.0	0.0	32.2	22.6	19.2	68.5	106.5	53.3	32.2	96.7	22.6	21.0	9.7	3.4	34.1	13.1	19.2	0.0
Water (tph)	2.5	11.4	8.2	21.5	15.0	12.8	1.8	2.7	124.3	35.9	96.7	52.6	102.8	65.5	39.9	208.2	105.4	2.1	219.6
% Solids (w/w)	0.0	0.0	0.0	60.0	60.0	60.0	97.5	97.5	30.0	47.3	50.0	30.0	17.0	12.9	7.8	14.1	11.0	90.0	0.0
Fe %	0.0	0.0	0.0	54.1	61.8	68.2	40.9	40.9	40.9	54.1	54.1	61.8	20.7	36.1	25.8	25.6	33.4	68.2	0.0
SiO2 %	0.0	0.0	0.0	18.7	10.7	4.7	22.6	22.6	22.6	18.7	18.7	10.7	28.6	37.4	44.5	32.7	39.2	4.7	0.0
STREAM NAME	Con Thickener OF	Tailings Return Water	Filtrate	Rougher Concentrate	Secondary Concentrate	Cleaner Concentrate	Primary Discharge	HPGR Product	PumpDischarge	PumpDischarge_2	PumpDischarge_3	PumpDischarge_4	Rougher Tails	Secondary Tails	Cleaner Tails	Tails_4	Tails_5	Filtered Concentrate	Process Water

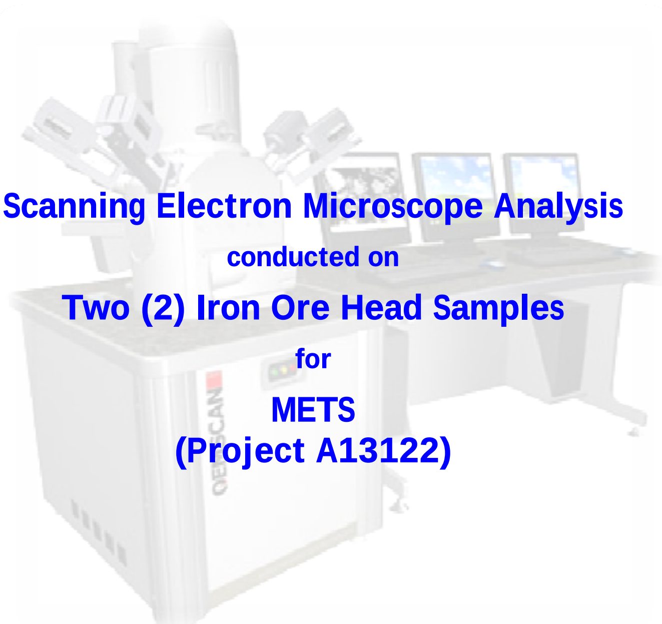
"The Flowsheet Processor"

DRAFT

Nelson Bay River Project

CLIENT	**Shree Minerals Limited**
JOB TITLE	**J491**
DESCRIPTION	**Magnetite Processing** **Mass Balance** **Area 000** **Sheet 1 of 1**
FILE	I:\jobs\J491 - Shree Minerals hematite DSO testwork\Controlled Documents\Mass Balances\J491 REF A

APPENDIX H – SCANNING ELECTRON MICROSCOPE ANALYSIS



Scanning Electron Microscope Analysis

conducted on

Two (2) Iron Ore Head Samples

for

METS
(Project A13122)

Mineralogy Report No.
MIN613 Addendum

February 2011

TABLE OF CONTENTS

SUMMARY

Two (2) iron ore head samples, which had previously been prepared and analysed via XRD, were further submitted to ALS-AMMTEC Mineralogy for manual EDS analysis. The aim of this study was to better understand if the high goethite levels detected during XRD analysis could be the cause of the inability to remove silicon from the final concentrate.

To achieve this, each of the samples were embedded into a resin block and cut-back and polished to a 1 µm diamond finish before loading into a SEM for analysis. Two fields from each of the samples were then imaged and several grains from each of the samples analysed via standardless EDS, to determine an estimate of the chemical composition of the grain.

A summary of relevant data and comments follows:

- Goethite in both samples showed variable levels of silicon, with some grains also containing aluminium, and a few grains containing phosphorous and manganese.

- All measured hematite were clean of other deleterious elements, within detection limits of the technique.

- Many, but not all, of the goethite and hematite grains were coated in a layer of fine-grained iron alumino-silicate, with the layers ranging from thin coats through to very thick coatings.

- Texturally, the goethite in the Head LG sample generally occurred as primary particles coated in the iron alumina-silicate, while the head HG sample also contained goethite and hematite in binary and ternary particles with silicate gangue.

- It is possible that the reason for the high silicon grade in the final product is due to a combination of the fine-grained coating on the goethite and hematite grains, the unliberated nature of the goethite and hematite in the Head HG sample, and the presence of substituted silicon in the goethite structure.

1. INTRODUCTION

Two (2) iron ore head samples, which had previously been prepared and analysed via XRD, were further submitted to ALS-AMMTEC Mineralogy for manual EDS analysis. The aim of this study was to better understand if the high goethite levels detected during XRD analysis could be the cause of the inability to remove silicon from the final concentrate.

The mineralogical work was requested by **Mr Lee Hung** (ALS-AMMTEC) on behalf of the project operator and was undertaken and supervised by **Dr Chi Vinh Ly** (ALS-AMMTEC Mineralogy).

2. SAMPLES RECEIVED

Details of the received samples are provided below:-

SAMPLES RECEIVED		
Sample ID	**Sample Type**	**Mineralogy Sample No.**
Head LG	**XRD Pulps**	MIN613A1A
		MIN613A2A

3. SAMPLE PREPARATION

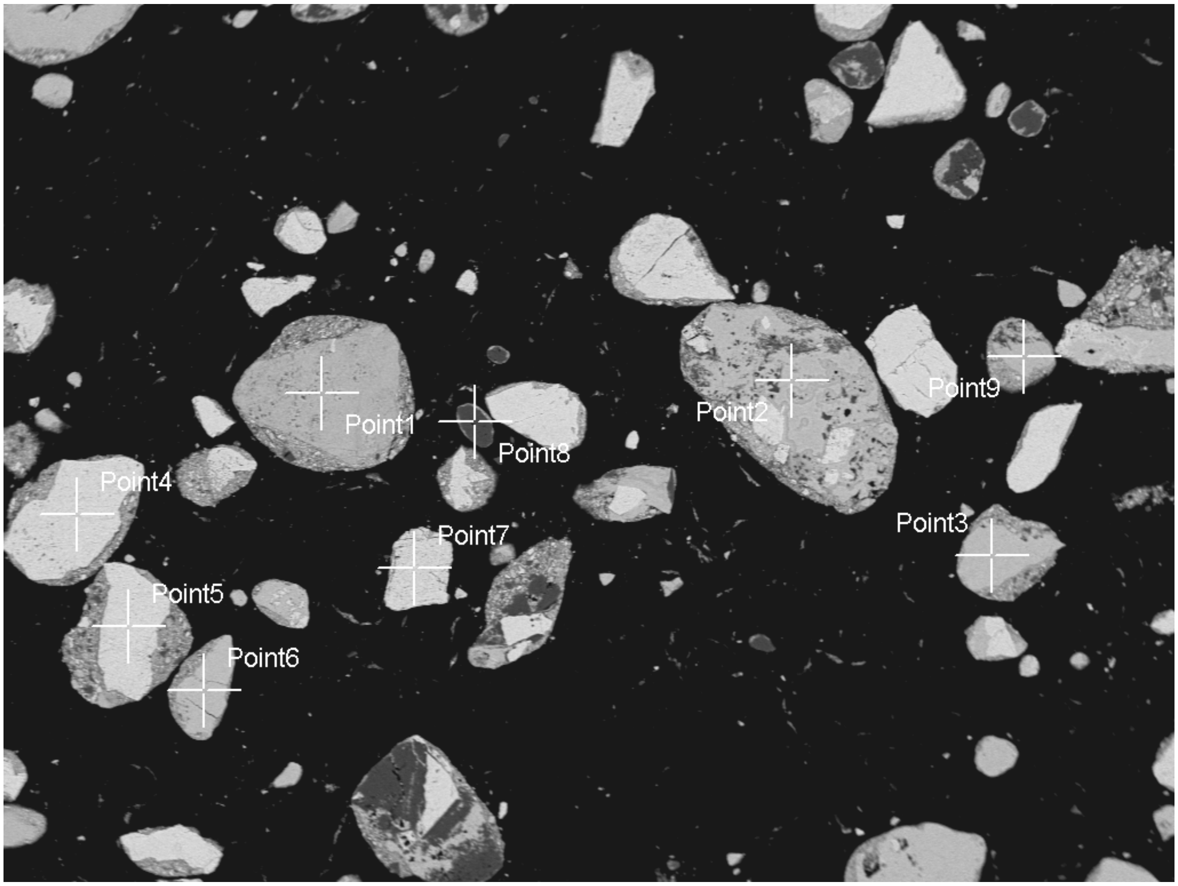
Representative aliquots of the XRD residue, from the original work, were riffled out and mounted into a two-part epoxy resin. Once set, the 30 mm resin blocks were cut back to expose fresh particle surfaces before fine polishing to a 1 µm diamond finish. The samples were then carbon coated and loaded into the instrument for analysis.

The analysis of the surfaces was completed via scanning electron microscope (SEM), which provides detailed images. The particles were also measured using standardless energy dispersive spectrometry (EDS), which provides an estimate of the chemical composition. The EDS analysis completed included spot analysis, with the spot analysis giving localised chemistry.

4. RESULTS – BSE AND EDS ANALYSIS

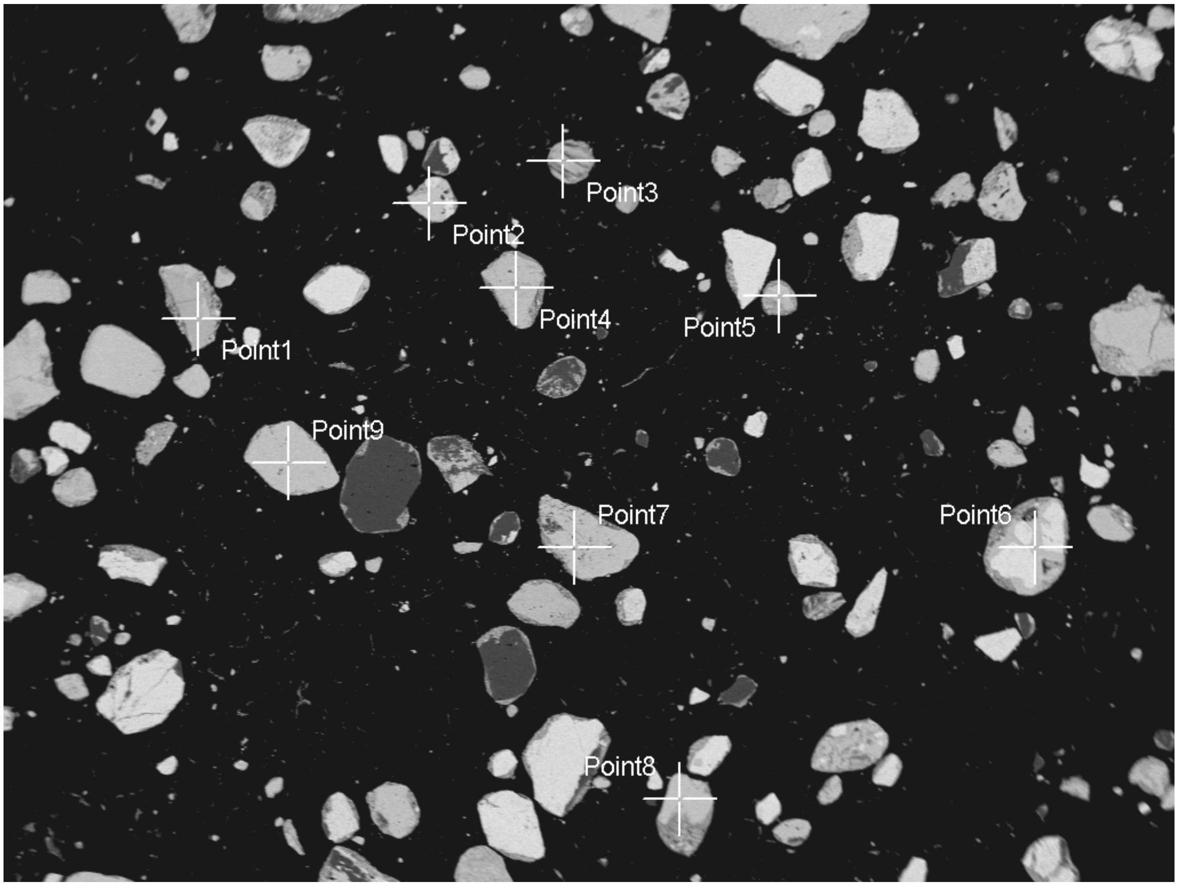
The grey scale of the back scattered electron images obtained reflect the average atomic number of the material. The brightest material in each field represents hematite, the intermediate greys are Goethite, the darker greys to dark greys representing silicates, and black represents the epoxy resin.

4.1 Head HG - Field 1



ELEMENTAL MASS % FOR FIELD 1								
	O	Mg	Al	Si	P	Ca	Mn	Fe
Point 1	27.2		0.8	1.1			0.6	70.2
Point 2	27.3		0.4	0.8			0.2	71.3
Point 3	27.5		0.3	0.7			0.3	71.2
Point 4	21.5							78.5
Point 5	21.0							79.0
Point 6	27.7			0.4				71.9
Point 7	21.4							78.6
Point 8	53.7			46.3				
Point 9	29.2		0.8	0.9				69.1

4.2 Head HG - Field 2



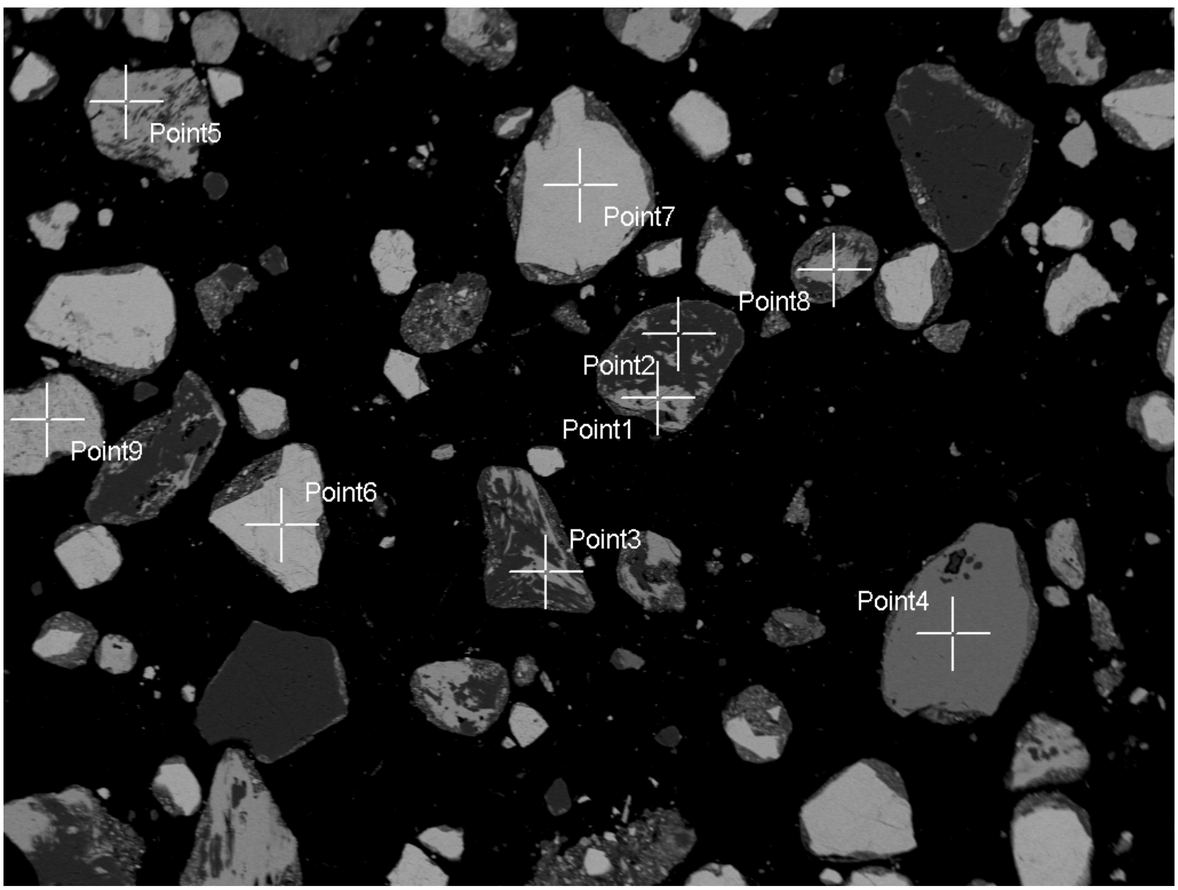
ELEMENTAL MASS % FOR FIELD 2								
	O	Mg	Al	Si	P	Ca	Mn	Fe
Point 1	29.4		2.3	0.5	0.3			67.5
Point 2	29.2			0.7				70.0
Point 3	27.2		0.5	0.5				71.9
Point 4	26.6		0.9	1.7				70.8
Point 5	29.3		1.2	0.5	0.4			68.6
Point 6	28.4		0.6	0.3	0.5			70.2
Point 7	29.3			1.4				69.3
Point 8	27.2		0.1	0.1				72.6
Point 9	27.4			0.7			1.0	71.0

- The EDS analysis of the goethite in the Head HG sample shows all goethite grains contain silicon; however, the amount of silicon in each grain is highly variable. In addition to silicon, some of the grains also contained aluminium.

- The analysis of hematite grains showed it to be clean of other deleterious elements, within the detection limit of the method.

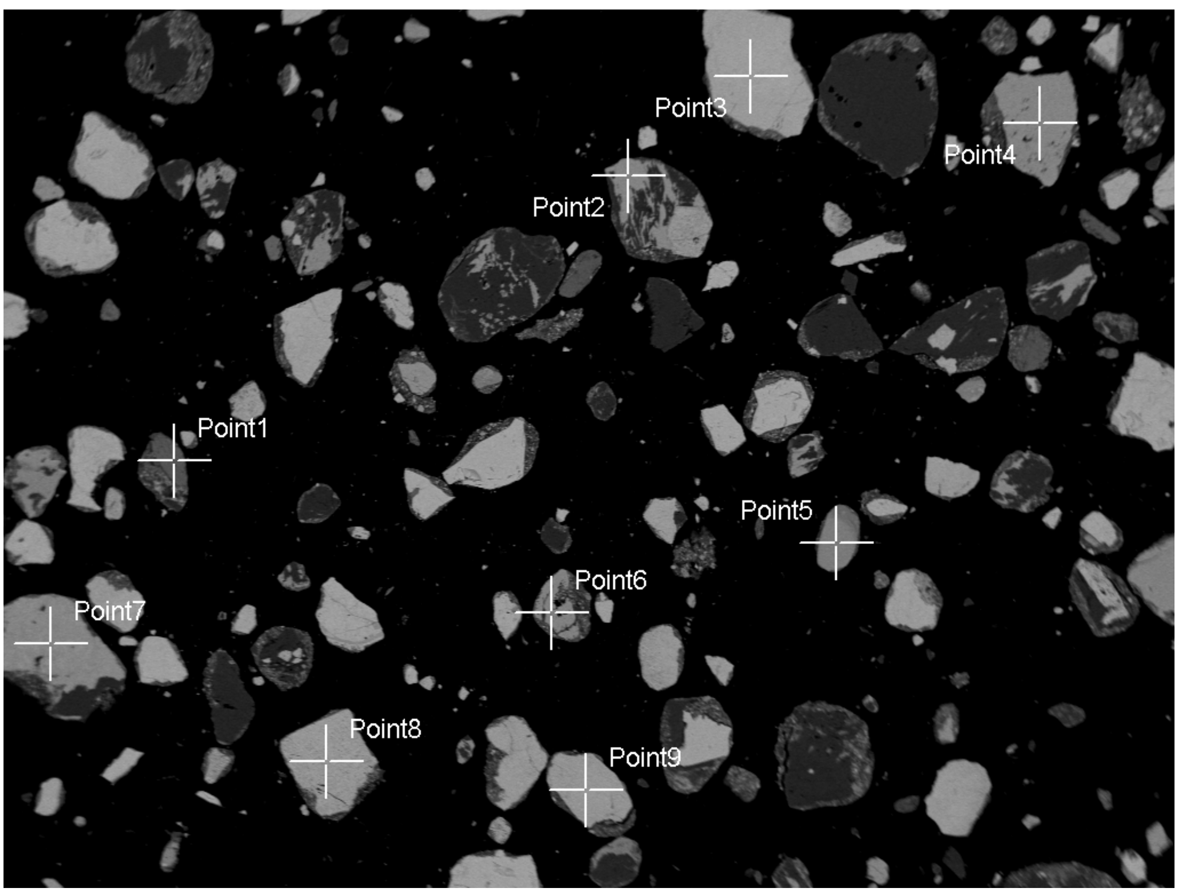
- Texturally, some of the goethite and hematite particles seem to be coated by a layer of fine-grained "cement", which contains highly variable levels of iron, silicon and aluminium. Aside from the coating, most hematite and goethite grains are discrete grains with only a few binary-ternary particles.

4.3 Head LG - Field 3



ELEMENTAL MASS % FOR FIELD 3								
	O	Mg	Al	Si	P	Ca	Mn	Fe
Point 1	28.2		1.0	0.7				70.2
Point 2	55.0			45.0				
Point 3	29.8		2.3	0.9				67.1
Point 4	28.4		12.3	15.5		3.1	18.4	22.2
Point 5	29.0		0.7	0.5				69.9
Point 6	19.5							80.5
Point 7	21.1		0.7					78.2
Point 8	30.7		1.3	9.7				58.3
Point 9	22.8		0.7	0.6				75.9

4.4 Head LG - Field 4



ELEMENTAL MASS % FOR FIELD 4								
	O	Mg	Al	Si	P	Ca	Mn	Fe
Point 1	32.8	6.2		23.9			2.7	34.5
Point 2	28.9			0.8				70.3
Point 3	21.9			0.3				77.8
Point 4	29.0			1.1				69.9
Point 5	30.8			1.5				67.7
Point 6	29.0			0.4				70.7
Point 7	27.7			0.5				71.9
Point 8	22.3			0.3				77.5
Point 9	20.1							79.9

- The EDS analysis of the goethite in the Head LG sample also shows silicon present in all goethite grains, with only some goethite also containing aluminium. As with the Head LG goethite, the level of silicon is variable in this sample.

- As with the Head HG sample, the hematite measured in this sample is also clean of deleterious elements, within detection limits of the method.

- Texturally, some of the goethite and hematite also contained a coating of fine-grained iron bearing silicate “cement”. However, unlike the Head LG sample, more of the goethite and hematite seem to occur as laths within larger silicate particles.

4.5 Summary of EDS Goethite

ELEMENTAL MASS % FOR GOETHITE IN ALL FIELDS								
Spot Name*	O	Mg	Al	Si	P	Ca	Mn	Fe
F1S1	27.2		0.8	1.1			0.6	70.2
F1S2	27.3		0.4	0.8			0.2	71.3
F1S3	27.5		0.3	0.7			0.3	71.2
F1S6	27.7			0.4				71.9
F1S9	29.2		0.8	0.9				69.1
F2S1	29.4		2.3	0.5	0.3			67.5
F2S2	29.2			0.7				70.0
F2S3	27.2		0.5	0.5				71.9
F2S4	26.6		0.9	1.7				70.8
F2S5	29.3		1.2	0.5	0.4			68.6
F2S6	28.4		0.6	0.3	0.5			70.2
F2S7	29.3			1.4				69.3
F2S8	27.2		0.1	0.1				72.6
F2S9	27.4			0.7			1.0	71.0
F3S1	28.2		1.0	0.7				70.2
F3S3	29.8		2.3	0.9				67.1
F3S5	29.0		0.7	0.5				69.9
F3S8	30.7		1.3	9.7				58.3
F3S9	22.8		0.7	0.6				75.9
F4S2	28.9			0.8				70.3
F4S3	21.9			0.3				77.8
F4S4	29.0			1.1				69.9
F4S5	30.8			1.5				67.7
F4S6	29.0			0.4				70.7
F4S7	27.7			0.5				71.9
F4S8	22.3			0.3				77.5
Average	**27.8**		**0.9**	**1.0**	**0.4**		**0.5**	**70.5**
Standard Deviation	**2.3**		**0.6**	**1.8**	**0.1**		**0.3**	**3.6**

* F = Field Number, S = Point Number, i.e. F1S2 = Field 1, Point 2

- A summary of the goethite grains measured via EDS in both the Head LG and Head HG sample shows an average silicon and aluminum concentration of ~1%. It should be noted that one of the grains showed nearly 10% silicon.
- The summary of goethite also shows some grains contained phosphorous and manganese, but concentration and number of grains are low.