Backfill Option Study
Interim Report
Weld Range Iron Ore Project

Report Prepared for

Sinosteel Midwest Corporation Limited

Prepared by

SRK Consulting

SMM001

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Interim Report
Weld Range Iron Ore Project

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Executive Summary

SRK Consulting (Australasia) Pty Ltd (SRK) has been retained by Sinosteel Midwest Corporation Limited (SMC) to carry out specific technical studies that form part of Bankable Feasibility Study (BFS) of the Weld Range Iron Ore Project. Backfilling of mine waste into the mined out pits is one of the key option studies under the awarded BFS scope of work.

The objective of this report is to provide progress on the ongoing Backfill Study. This study has also highlighted possible improvements to blending options that will be considered in future studies.

The mining schedule presented in the Weld Range Iron Ore Project Pre Feasibility Study (PFS) has been taken as base case to draw comparisons against the backfilling schedule scenarios. Various mining scenarios have been considered by altering the pit mining sequence and varying the Run of Mine (RoM) stockpile capacity. The target product grades have been kept constant and are consistent to those used in PFS.

This report presents a summary of one such feasible scheduling scenario (Scenario 1a). Scenario 1a is feasible without the requirement of any stockpiles or special grade control measures. Moreover, considerable improvements in results are expected as the study progresses. Scenario 1a is summarised in the following table.

Period	Ore kt	Fe %	SiO_2 %	Al_2O_3 %	Waste kt	Strip Ratio	RoM Stockpile Reclaim kt	Mineralised Waste Stockpile kt
1	4,947	60.03%	4.36%	2.10%	36,904	8.2	0	3,844
2	15,107	59.85%	4.58%	2.09%	118,280	7.8	0	0
3	15,996	59.89%	4.60%	2.02%	81,936	5.1	0	0
4	14,918	60.36%	4.49%	2.10%	98,643	6.6	0	0
5	7,175	60.92%	3.88%	2.08%	35,578	5.0	0	0
6	4,955	60.16%	4.32%	2.08%	12,028	2.4	0	0
Total (Backfilling Scenario 1a)	**63,099**	**60.14%**	**4.45%**	**2.08%**	**383,368**	**6.1**	**0**	**3,844**
PFS	**61,091**	**60.28%**	**4.36%**	**2.07%**	**355,270**	**5.8**	**2,029**	**1,666**

In the table, the material reported in the Mineralised Waste stockpile is out of grade specifications, such that it cannot be blended to meet the target product grade. Therefore, this material is either stored as a separate stockpile for future reclamation or directed to the waste dumps. The material reported as RoM Stockpile is ore which is stockpiled and reclaimed at a later stage for product.

The term waste in the Strip Ratio includes any off-specification material which has been stockpiled at the end of the schedule. These stockpiles include the Mineralised Waste stockpile.

It is worth noting that there was about two million tonnes of unreclaimed RoM in PFS. The lack of RoM stockpiling in Scenario 1a makes the schedule simpler, yet produces more product when compared to PFS schedule.

Backfill proportions are calculated based on the amount of waste which is available from adjacent pits to fill in mined out pit voids. It is an iterative process and a function of stockpile capacity and pit mining sequence.

Backfill proportions demonstrated in Scenario 1a are 26% of the waste volume for Beebyn and 10% of the waste volume for Madoonga deposit.

The results from Scenario 1a have demonstrated that maintaining backfilling whilst mining is feasible, but only limited quantities of waste are able to be stowed in-pit. Elevating the backfilling process to be the primary mine production schedule driver and allowing stockpiles to feed the blended grade is expected to show improvement in results. The ongoing scheduling study is in progress with further scenarios being considered.

Recommendations

The timing and sequence of extraction plays an important role in determining the backfilling potential. Backfilling is limited in the Scenario 1a and only some portion of the pits may be opportunistically backfilled, with the major proportion of the waste reporting to external waste dumps. Thus, for this scenario, the dump footprints would not change considerably from those indicated in the Weld Range Iron Ore Project PFS.

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (Australasia) Pty Ltd (SRK) by Sinosteel Midwest Corporation Limited (SMC). The opinions in this Report are provided in response to a specific request from SMC to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

List of Abbreviations

Abbreviation	Meaning
Al_2O_3	Alumina content in %
BCM	Bank cubic meters
BFS	Bankable Feasibility Study
Fe	Iron content in %
k	thousand
kg	kilogram
m	metre
M	million
m RL	metres reduced level
m^3	cubic metre
Mt	million tonnes
PFS	Pre Feasibility Study
ROM	run of mine
SiO_2	Silica content in %
SMC	Sinosteel Midwest Corporation Limited
SRK	SRK Consulting (Australasia) Pty Ltd
t	Tonne
tpa	tonnes per annum

1 Introduction

SRK Consulting (Australasia) Pty Ltd (SRK) has been retained by Sinosteel Midwest Corporation Limited (SMC) to carry out the Bankable Feasibility Study (BFS) of the Weld Range Iron Ore Project. Backfilling of mine waste into the mined out pits is one of the key option studies under the BFS scope of work.

Backfilling is the process of utilising mined out pit voids to store the waste from adjacent operating pits. Generally, one pit is mined out early in the production schedule so that it can be utilised as a dumping location for other pits. This reduces the external waste dump size and hence the external dump footprint.

Backfilling impacts on the ore mine production schedule. The greater the onus on backfilling, the more constrained the mine production schedule becomes and the more difficult it becomes to achieve the blended grade requirements. Optimising the backfilling scenarios requires considerable schedule manipulation.

The use of external Run of Mine (RoM) stockpiles play an important role in providing the required blend.

This study focuses on achieving the target grade specifications to meet the plant requirements and at the same time, sequencing the pits in a manner such that they can be backfilled.

2 Objective

The object of this study is to assess the feasibility of backfilling the mined out pits. The basis for comparison to non backfilling options is the results from the prior Weld Range Iron Ore Project Pre Feasibility Study (PFS) designs and mine production schedules.

A practical mining schedule needs to be generated which caters to the backfilling requirements as well as maintaining the RoM feed grade specifications.

In this study, various scenarios on backfilling sequence are being considered. At the same time the feed grade target specifications were kept constant.

The fines specification target for the annual mine production schedule are shown in Table 2-1:

Table 2-1: Fines target grade

Element / mineral	Fines Target Grade
Fe	> 58%
SiO_2	< 5.5%
Al_2O_3	< 2.6%

Following regression equations were used to convert the fines target grades to Feed / ROM specifications:

Madoonga:

Fines Fe = 1.121 * Feed Fe -8.190
Fines SiO_2 = 1.140 * Feed SiO_2 + 0.291
Fines Al_2O_3 = 1.152 * Feed Al_2O_3 + 0.097

Beebyn:

Fines Fe = 1.149 * Feed Fe – 10.061
Fines SiO_2 = 1.227 * Feed SiO_2 – 0.134
Fines Al_2O_3 = 1.066 * Feed Al_2O_3 + 0.487

The ROM / Feed specifications for each deposit are shown in Table 2-2. The target specifications for ROM grades of the two deposits are different depending upon the regression equations shown above.

Table 2-2: ROM specifications by deposit

Element / mineral	Madoonga ROM Target Grade	Fines Target Grade
Fe	> 59.04%	> 58%
SiO_2	< 4.57%	< 5.5%
Al_2O_3	< 2.52%	< 2.6%
Element / mineral	**Beebyn ROM Target Grade**	**Fines Target Grade**
Fe	> 59.23%	> 58%
SiO_2	< 4.59%	< 5.5%
Al_2O_3	< 1.98%	< 2.6%

On an average following constraints on ROM grade were applied to the scheduling packages as in Table 2-3:

Table 2-3: ROM specifications applied

Element / mineral	ROM Target Grade
Fe	> 59%
SiO_2	< 4.6%
Al_2O_3	< 2.1%*

* The Al_2O_3 target grade is achieved after numerous scheduling runs and iterative calculations for the fines grade according to Madoonga and Beebyn breakup of ore tonnes.

3 Backfill Scheduling

3.1 Software

Three software packages, MineSight - Strategic Planner, MineMAX and Excel were used for the scheduling purpose, and the results combined into one solution.

3.2 New variables in block model

New variables were coded in the mineral resource model to enable scheduling in the software packages. These are:

- COMBO – combination integer item, numbered from 0 to 37 representing various classes of Fe, SiO_2 and Al_2O_3 content;
- ZACOM – Pushback number;
- OREN% – New Ore% item to reflect silica cut-off; and
- PART% – Partials percent.

3.3 Considerations

Depending on the annual division of production between Madoonga and Beebyn, the fines grade will vary period by period. This variation is not expected to be significant and can easily be controlled by employing grade control measures.

A maximum vertical advance of eight benches (96 m) per year has been selected.

A specific backfilling constraint was considered but not optimised.

Other considerations were:

- backfilling to commence at first opportunity when a stage is mined out;
- a swell factor of 30% to be allowed for the loose backfilled waste;
- no planned loss of backfill capacity compared to the mined out volumes;
- no partial mining of two benches within any stage at any time is required; and
- no sub-classification of bench reserves for Scenario 1a. (Easiest possible grade control).

3.4 Scenarios

Various mine production scheduling scenarios are planned to be considered to test the backfilling options and implications on the project. This includes the use of stockpiles and sequencing of mine production and the pit development sequence. Scenario 1a presented in this report has no stockpiles.

The scenarios planned to be developed include:

- Scenario 1a: as reported, no stockpiles, PFS pit development order;
- Scenario 1b: proposed, with stockpiles, PFS pit development order; and
- Scenario 2a: proposed, no stockpiles, reverse order of pit development.

3.5 Scheduling runs

Numerous scheduling runs were performed. The mine production schedule, Scenario 1a, was achieved without applying sub-classification to the bench reserves. Thus, the material in a bench was either sent to mill or to waste dump; or left in situ.

3.6 Results

The key results of Scenario 1a are that the proportion of backfill over total waste production is 26% of the waste volume for Beebyn, and 10% of the waste volume for Madoonga. A summary of ore quantity, grades and the waste volumes to be moved is shown in Table 3-1.

Table 3-1: Summary

Period	Ore quantity (t)	Waste quantity (t)	Waste Volume (m^3)	Fe %	SiO_2 %	Al_2O_3 %	P %	LOI %	S %
1	4,947,342	36,903,734	13,729,628	60.03%	4.36%	2.10%	0.09%	6.54%	0.06%
2	15,106,769	118,279,697	44,876,851	59.85%	4.58%	2.09%	0.08%	6.69%	0.05%
3	15,996,109	81,935,839	31,235,866	59.89%	4.60%	2.02%	0.07%	6.81%	0.06%
4	14,918,405	98,643,166	37,547,954	60.36%	4.49%	2.10%	0.08%	6.10%	0.04%
5	7,175,030	35,577,512	13,669,855	60.92%	3.88%	2.08%	0.10%	6.03%	0.01%
6	4,955,067	12,028,287	4,745,000	60.16%	4.32%	2.08%	0.08%	6.76%	0.03%
Total	**63,098,722**	**383,368,235**	**145,805,154**	**60.14%**	**4.45%**	**2.08%**	**0.08%**	**6.50%**	**0.05%**

Period 1 is a similar ramp up period to that indicated in the PFS report. This does not include four months of pre-strip and the pre-strip material movements. After the ramp up Period (1) the remaining periods are regular production years. In the later Periods (5 and 6) the plant capacity of 15 Mtpa is not met due to:

- scheduling limitations (thought to get better in later scenarios) and material left out in pit;
- extra ore above target being mined out in Period (3); and
- not enough pit inventory.

Figure 3-1 shows the trend in ore and waste quantities to be mined in each period for the Scenario 1a. Similarly, Figure 3-2 and Figure 3-3 show the feed grades by period. Comments are included in the figures to highlight where fine tuning could result in better results.

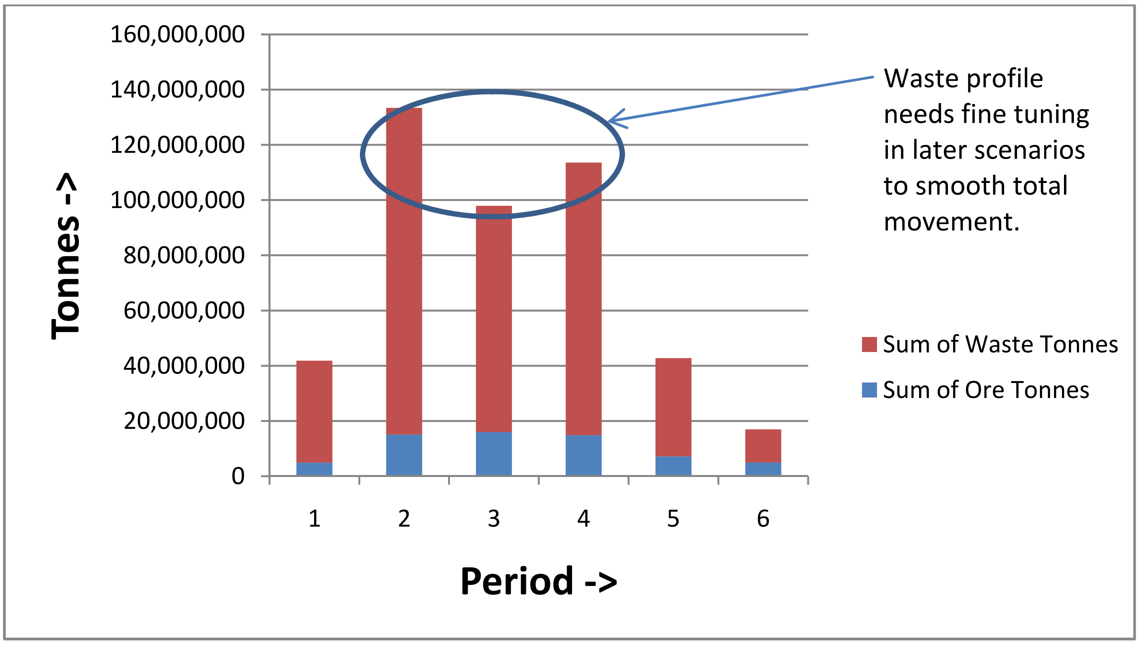

Figure 3-1: Ore and Waste quantity by Period (Scenario 1a)

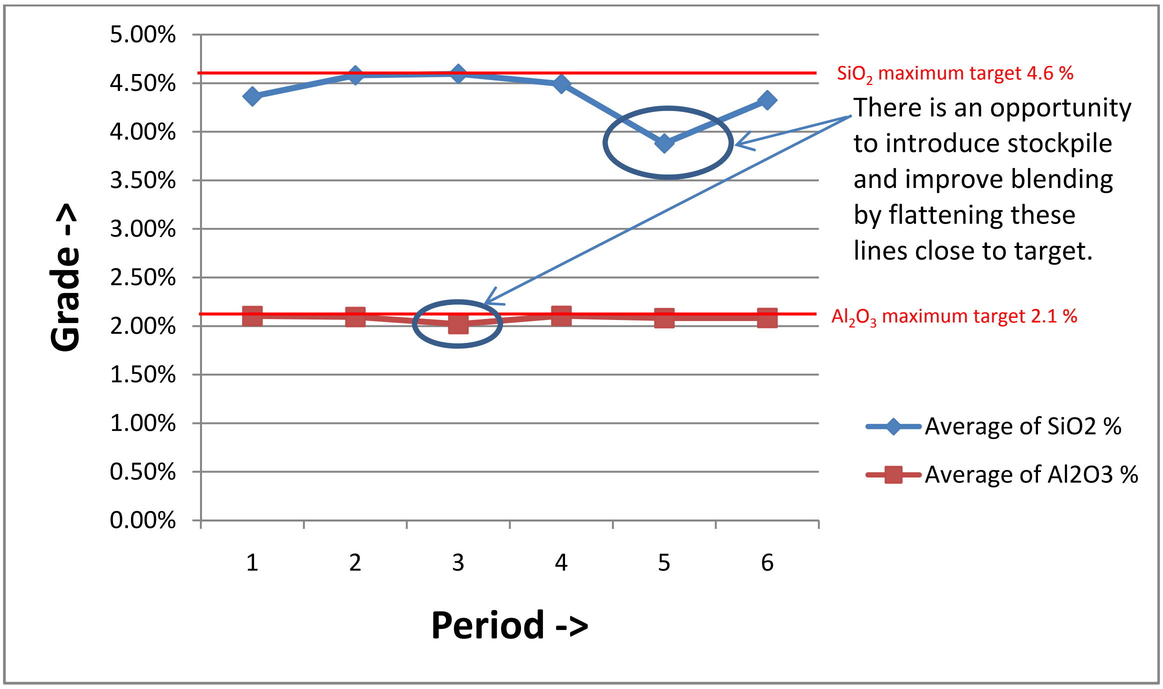

Figure 3-2: Average contaminant grades by Period (Scenario 1a)

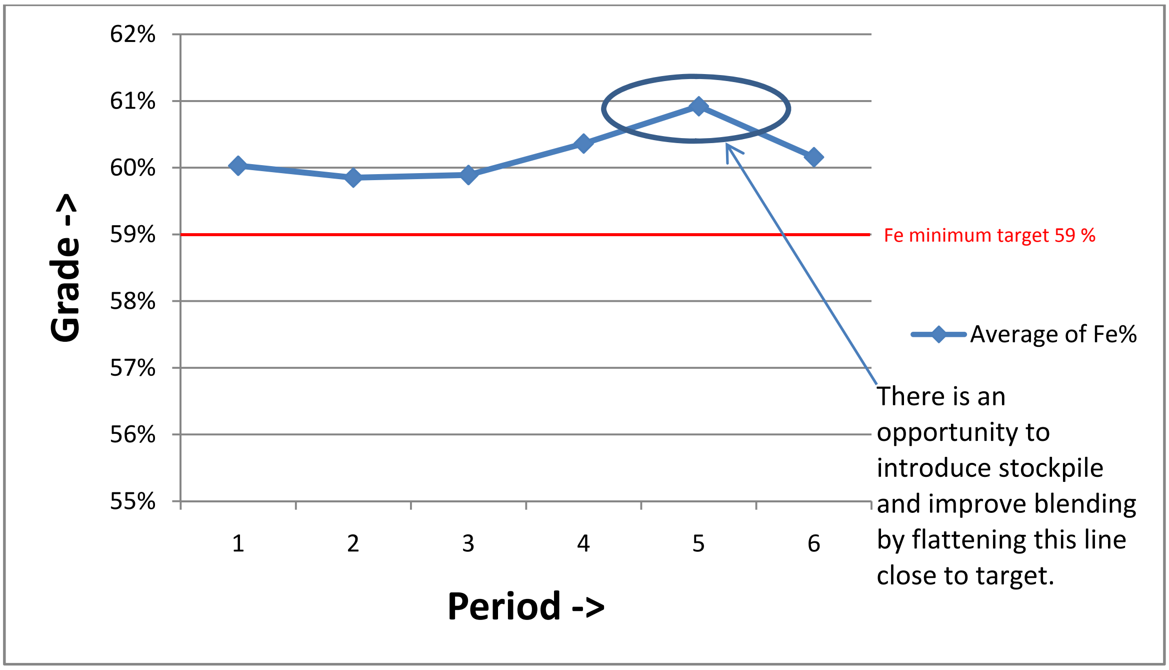

Figure 3-3: Average Fe grade by period (Scenario 1a)

Table 3-2 shows the pit by pit ore quantities to be mined in different periods for Scenario 1a. It is worth noting that there is 2.4 Mt of un-scheduled material which is left in situ.

There an additional 3.8 Mt of material shown under the Period '1s'. Period '1s' represents an imaginary stockpile, which allows the scheduling package some flexibility in performing the scheduling calculations. This material under Period '1s' is such that it cannot be blended to meet the target grade specifications. Therefore, this mineralised material can be stored in a separate stockpile or directed to waste dumps. Similarly, there is a scarce amount of material shown under Period '2s' which means that it is mined in second period and that the material is not a part of the feed to the processing plant.

The reporting of Period ‘1s’ and ‘2s’ is included as other production scenarios will manage this material in different ways, and the reporting improves the transparency between the scenario options.

Table 3-2: Pit by pit Ore by Period (Scenario 1a)

Ore Tonnes by Period										
Pit	**1**	**2**	**3**	**4**	**5**	**6**	**1s**	**2s**	**Un-scheduled**	**Grand Total**
Beebyn_Main_Central				2,881,254	244,618				228,793	3,354,665
Beebyn_Main_East	788,847	3,397,762	3,805,981	2,129,247						10,121,837
Beebyn_Main_West_1				4,504,303	5,806,163	2,891,623			248,492	13,450,581
Beebyn_Main_West_2		48,295	373,392	1,536,146	1,124,249					3,082,082
Beebyn_Pod_Central		312,946	576,049	38,924						927,919
Beebyn_Pod_East		132,670		295,417						428,087
Beebyn_Pod_West		656,616	1,265,879	32,470						1,954,965
Madoonga_Stage_1	4,158,495	7,752,217	3,466,109				3,844,507			19,221,328
Madoonga_Stage_2			3,599,506	1,116,995		2,063,444			1,854,871	8,634,816
Madoonga_Stage_3		2,806,263	2,909,193	2,383,649				56	99,151	8,198,312
Grand Total	**4,947,342**	**15,106,769**	**15,996,109**	**14,918,405**	**7,175,030**	**4,955,067**	**3,844,507**	**56**	**2,431,307**	**69,374,592**

Table 3-3 shows the pit by pit waste mining in various periods for Scenario 1a. Waste shown under Period '1s' is the waste mined out from the same benches as the mineralised material (shown in Table 3-2) mined out under the same Period ‘1s’. In this scenario, this waste material can be assumed to be mined under Period 1 and directed to waste dump.

Table 3-3: Pit by pit Waste by Period (Scenario 1a)

Waste Tonnes by Period										
Pit	**1**	**2**	**3**	**4**	**5**	**6**	**1s**	**2s**	**Un-Scheduled**	**Grand Total**
Beebyn_Main_Central				15,117,669	679,531				621,912	16,419,112
Beebyn_Main_East	2,543,134	48,471,482	28,567,220	6,604,574						86,186,410
Beebyn_Main_West_1				46,935,398	32,208,925	6,910,087			145,282	86,199,692
Beebyn_Main_West_2		963,673	4,545,790	20,158,375	2,689,056					28,356,894
Beebyn_Pod_Central		3,942,889	2,445,754	19,359						6,408,002
Beebyn_Pod_East		1,809,567		3,590,364						5,399,931
Beebyn_Pod_West		6,976,566	5,681,928	13,873						12,672,367
Madoonga_Stage_1	20,425,774	30,815,240	6,305,695				13,934,826			71,481,535
Madoonga_Stage_2			26,769,144	3,419,998		5,118,200			4,302,550	39,609,892
Madoonga_Stage_3		25,286,254	7,620,308	2,783,556				14,026	47,735	35,751,879
Grand Total	**22,968,908**	**118,265,671**	**81,935,839**	**98,643,166**	**35,577,512**	**12,028,287**	**13,934,826**	**14,026**	**5,117,479**	**388,485,714**

Backfilling percentage has been calculated based on the amount of material that can be potentially backfilled in the void space created with the view to highlight the amount of material which is potentially available for backfilling in a given scenario. It is the intention to keep the reporting simple, and allow more detailed reporting in the final report when other scenarios are available for comparison and contrast.

Due to the varied ore-waste translation from one scenario to other and the variation in densities from pit to pit, the void created by mining ore has been ignored in this interim report. The void created by waste mining, and loose (swelled) backfilled waste volume is used for calculating the backfilling percentage.

It can be observed from Table 3-2 that Beebyn Main East pit gets completely mined out in Period 4 and that Madoonga Stage 1 pit gets completely mined out in Period 3. Henceforth, these pit voids are available for backfilling. Table 3-3 highlights the amount of waste that would be available from adjacent pits for backfilling these voids.

In Table 3-3, light blue background highlights the material which can be potentially backfilled in Beebyn Main East pit and light green background highlights the material which can be potentially backfilled in Madoonga Stage 1 pit. The sum of the quantities is 42.5 and 11.3 Mt, respectively.

Table 3-4 highlights these quantities as a percentage of the pit waste quantities. As the quantity of material that is shown in this table is expressed in tonnes, there is no account for a swell factor. A swell factor of 30% is allowed for in the volumetric calculations later in this section.

Table 3-4: Backfill percentage by quantity (Scenario 1a)

Category	Quantity (Mt)	Backfill quantity (percent)
Beebyn Main total waste	216.40	20%
Beebyn Main Backfilled waste	42.49	
Madoonga total waste	142.49	8%
Madoonga Backfilled waste	11.32	
Combined total waste	358.89	15%
Combined backfilled waste	53.81	

Table 3-5 shows the pit by pit waste volume movements in BCM. Similar calculations as explained previously in this section apply for the backfilling percentage calculation. The results are shown in Table 3-6. It is worth noting that, unless a swell factor is applied, the backfilling percentage is the same when observed with respect to quantity or with respect to volume. This is evident when comparing Table 3-4 and Table 3-6.

Table 3-5: Pit by pit Waste volume by Period (Scenario 1a)

Waste volume by Period (BCM)										
Pit	**1**	**2**	**3**	**4**	**5**	**6**	**1s**	**2s**	**Un-Scheduled**	**Grand Total**
Beebyn_Main_Central				5,916,143	232,200				206,225	6,354,568
Beebyn_Main_East	976,382	18,335,426	11,046,209	2,320,367						32,678,384
Beebyn_Main_West_1				17,660,241	12,481,408	2,736,633			47,597	32,925,879
Beebyn_Main_West_2		366,290	1,778,179	7,716,986	956,247					10,817,702
Beebyn_Pod_Central		1,352,846	835,478	6,188						2,194,512
Beebyn_Pod_East		700,983		1,461,636						2,162,619
Beebyn_Pod_West		2,659,689	2,117,751	3,604						4,781,044
Madoonga_Stage_1	7,679,331	11,822,377	2,184,905				5,073,915			26,760,528
Madoonga_Stage_2			10,127,165	1,361,116		2,008,367			1,623,050	15,119,698
Madoonga_Stage_3		9,634,367	3,146,179	1,101,673				4,873	18,528	13,905,620
Grand Total	**8,655,713**	**44,871,978**	**31,235,866**	**37,547,954**	**13,669,855**	**4,745,000**	**5,073,915**	**4,873**	**1,895,400**	**147,700,554**

Table 3-6: Backfill percentage by volume (theoretical calculation only, no swell) (Scenario 1a)

Category	Volume (million BCM)	Backfill volume* (percent)
Beebyn Main total waste void	82.50	20%
Beebyn Main Backfilled waste	16.41	
Madoonga total waste void	54.14	8%
Madoonga Backfilled waste	4.47	
Combined total waste	136.67	15%
Combined backfilled waste	20.88	

*No swelling factor allowed for, at this stage.

Table 3-7: Backfill percentage by volume with a 30% swell factor on waste volume (Scenario 1a)

Category	Volume (million m^3)	Swell factor	Swelled volume (million m^3)	Backfill (Volume percent) (accounting for swell)
Beebyn Main void	82.50			26%
Beebyn Main Backfilled waste	16.41	1.3	21.3	
Madoonga void	54.14			10%
Madoonga Backfilled waste	4.47	1.3	5.8	
Combined void	136.67			19%
Combined backfilled waste	20.88	1.3	27.1	

Table 3-7 shows the actual volumetric calculations based on swelled backfilling material volumes. A swell factor of 1.3 (or 30%) is applied. It is to be observed that the backfilled waste swells but not the void volume, so the swelling factor is applied only to the backfilled waste row in the above table. The backfill percent in the last column is calculated as a ratio of swelled backfill volume to the void volume.

4 Conclusions and Recommendations

4.1 Conclusion

The Scenario 1a mine production schedule presented in this report is a feasible backfill solution.

Scenario 1a also indicates a total of **63 of total the 69 million tonnes (or 91%)** ore was scheduled, without the need for external RoM stockpiles and with no grade bins to sub-classify the bench reserves. The schedule is not optimised in terms of backfill constraints and stockpile utilisation. Making backfilling the primary schedule driver and allowing stockpiles to feed the blended grade, is expected to show improvement in the results.

At this stage, results from this schedule have demonstrated that backfilling, is feasible but to a limited extent. The ongoing scheduling scenario work outlined below is expected to improve the results.

4.2 Recommendations

Lump / fine grade regressions have been coded into the Resource model to allow for precise ongoing blending and backfilling studies.

SRK recommends future and ongoing work to proceed in the direction indicated below.

4.2.1 Quarterly schedule

The schedule presented here has yearly time periods. Average grades mined in these periods are very close or the same as target grade specifications. There is a concern that although annual target for grade specifications and tonnage be met by the schedule, it might be difficult to feed the target blend in shorter periods of time such as on a quarterly or monthly basis.

SRK recommends generating a quarterly schedule to assess and demonstrate the practicality of feeding the blended grade.

4.2.2 Scheduling scenarios

Various changes in constraints have different impact on the schedule and hence the mining sequence. Therefore, various scenarios are to be considered and the optimal case be selected for fine tuning. Examples of scenarios to be considered are mentioned below.

- Backfill Madoonga Stage 3 first.
- Relax backfill constraint on Beebyn.
- Consider backfilling Beebyn Pods.

4.2.3 Balance backfill vs stockpile capacity

Waste backfill amount depends on the mining sequence, as pits to be backfilled need to be sequenced earlier in the mining schedule. Also, the sequence has to be such that the target grade specifications are met. To achieve this, some material, which cannot be directly fed to the plant, needs to be stockpiled and blended with appropriate material being mined at a later date. This blend is then fed to the plant. This is a two step iterative process.

- Optimise for backfill, assess variations on backfill constraints.
- Optimise Stockpiles capacity for effective blending.

4.2.4 Improve resource to reserve conversion. (63 Mt / 69 Mt in the current schedule)

In the schedule presented here 63 Mt of ore is fed to the plant. The rest is not able to be blended to meet the target grade specifications.

This resource to reserve conversion needs to be improved by sequencing variations and by utilising stockpiles to create the blend. Higher the reserve, higher is the project value.

Although total movement increases as compared to PFS schedule, the project value increases. This is because the PFS designs are optimum on the assumption that all of 69 Mt can be blended and processed.

4.2.5 Smooth waste profile

A smooth waste profile is desirable as it will help better negotiate a mining contract. The equipment required for the movement wouldn’t change much over the years making it logistically easy to carry out the operations.

5 References

Murray Carl, *Pre Feasibility Mining Study Weld Range Iron Ore Project*, SRK Consulting (Perth, November 2008)

Appendices

Appendix 1: Bench by Bench Schedule

PIT	Bench	Period	Ore Tonnes	Waste Tonnes	Waste BCM	SR	FE%	SIO2%	AL2O3%	P%	LOI%	S%
Beebyn_Main_East	540	1	223,000	400,942	139,695	1.8	64.15	2.87	2.53	0.07	1.87	0.01
Beebyn_Main_East	528	1	565,847	2,142,192	836,687	3.8	64.49	2.8	2.49	0.05	1.70	0.02
Beebyn_Main_East	516	2	637,268	6,924,207	2,707,373	10.9	64.4	2.83	2.48	0.05	1.72	0.02
Beebyn_Main_East	504	2	687,271	11,983,682	4,474,604	17.4	64.35	2.9	2.43	0.06	1.86	0.01
Beebyn_Main_East	492	2	698,642	11,378,842	4,263,395	16.3	64.57	2.78	2.34	0.06	1.86	0.01
Beebyn_Main_East	480	2	691,642	9,827,132	3,712,554	14.2	64.44	2.89	2.2	0.06	1.92	0.01
Beebyn_Main_East	468	2	682,939	8,357,619	3,177,500	12.2	64.53	2.76	2.04	0.06	1.93	0.01
Beebyn_Main_East	456	3	647,444	7,040,466	2,713,808	10.9	64.64	2.43	1.91	0.05	1.98	0.00
Beebyn_Main_East	444	3	626,835	5,898,942	2,305,450	9.4	64.23	2.54	1.94	0.05	2.14	0.00
Beebyn_Main_East	432	3	627,354	4,981,482	1,957,825	7.9	64.03	2.69	1.97	0.05	2.10	0.00
Beebyn_Main_East	420	3	632,608	4,215,541	1,640,394	6.7	64.33	2.79	1.9	0.05	1.82	0.00
Beebyn_Main_East	408	3	638,494	3,511,444	1,341,667	5.5	64.66	2.77	1.74	0.05	1.54	0.00
Beebyn_Main_East	396	3	633,246	2,919,345	1,087,065	4.6	64.96	2.53	1.66	0.05	1.53	0.00
Beebyn_Main_East	384	4	607,197	2,342,634	852,723	3.9	64.93	2.41	1.56	0.06	1.80	0.01
Beebyn_Main_East	372	4	544,470	1,843,167	652,638	3.4	64.87	2.36	1.44	0.06	1.97	0.01
Beebyn_Main_East	360	4	463,317	1,394,343	477,886	3.0	64.9	2.22	1.46	0.07	2.16	0.01
Beebyn_Main_East	348	4	324,156	707,448	235,797	2.2	65.14	2.05	1.46	0.06	2.13	0.01
Beebyn_Main_East	336	4	146,762	246,457	79,295	1.7	65.81	1.94	1.47	0.05	1.55	0.00
Beebyn_Main_East	324	4	43,345	70,525	22,028	1.6	66.12	1.87	1.45	0.04	1.41	0.00
Beebyn_Main_Central	528	4	1,313	13,286	3,760	10.1	57.44	5.8	2.46	0.17	8.90	0.02
Beebyn_Main_Central	516	4	206,598	1,829,153	701,861	8.9	60.16	5.54	2.35	0.11	5.58	0.02
Beebyn_Main_Central	504	4	292,954	2,994,709	1,186,437	10.2	60.42	5.45	2.33	0.11	5.23	0.01
Beebyn_Main_Central	492	4	346,722	2,565,258	1,029,815	7.4	60.65	5.48	2.29	0.10	4.91	0.01
Beebyn_Main_Central	480	4	388,366	2,209,630	890,461	5.7	60.81	5.68	2.2	0.09	4.55	0.01
Beebyn_Main_Central	468	4	418,790	1,889,863	748,757	4.5	60.75	6.01	2.07	0.07	4.29	0.01
Beebyn_Main_Central	456	4	442,399	1,541,854	595,977	3.5	60.28	6.4	1.89	0.06	4.22	0.01
Beebyn_Main_Central	444	4	428,196	1,160,185	436,895	2.7	59.64	6.74	1.83	0.06	4.25	0.02
Beebyn_Main_Central	432	4	355,916	913,731	322,180	2.6	58.47	6.86	1.75	0.06	4.57	0.03
Beebyn_Main_Central	420	5	244,618	679,531	232,200	2.8	57.38	7.01	1.71	0.06	5.18	0.03
Beebyn_Main_Central	408	Un-Scheduled	116,791	403,616	134,992	3.5	57.59	6.51	1.71	0.04	5.49	0.05
Beebyn_Main_Central	396	Un-Scheduled	79,888	183,058	60,294	2.3	57.53	6.55	1.66	0.03	5.98	0.06
Beebyn_Main_Central	384	Un-Scheduled	32,114	35,238	10,939	1.1	58.59	6.33	1.43	0.03	5.06	0.09
Beebyn_Main_West_1	552	4	26,402	47,365	17,248	1.8	60.85	2.91	2.4	0.11	6.62	0.07
Beebyn_Main_West_1	540	4	286,628	1,011,029	427,948	3.5	61.15	3.07	2.61	0.09	6.20	0.11
Beebyn_Main_West_1	528	4	608,002	4,803,971	1,896,503	7.9	61.2	3.3	2.57	0.09	6.02	0.10
Beebyn_Main_West_1	516	4	798,707	11,080,798	4,112,099	13.9	60.96	3.43	2.48	0.10	6.15	0.07
Beebyn_Main_West_1	504	4	885,121	11,315,100	4,186,117	12.8	61.07	3.34	2.39	0.10	6.08	0.04
Beebyn_Main_West_1	492	4	928,625	9,932,809	3,718,978	10.7	61.12	3.31	2.31	0.11	6.09	0.02
Beebyn_Main_West_1	480	4	970,818	8,744,326	3,301,348	9.0	61.17	3.31	2.33	0.11	6.17	0.01
Beebyn_Main_West_1	468	5	1,016,959	7,588,109	2,893,107	7.5	61.18	3.31	2.31	0.11	6.16	0.01
Beebyn_Main_West_1	456	5	1,018,875	6,656,479	2,548,513	6.5	61.29	3.46	2.24	0.11	5.97	0.01
Beebyn_Main_West_1	444	5	988,903	5,722,665	2,222,313	5.8	61.31	3.65	2.25	0.10	5.75	0.01
Beebyn_Main_West_1	432	5	962,896	4,891,352	1,910,159	5.1	61.26	3.74	2.22	0.10	5.55	0.01
Beebyn_Main_West_1	420	5	928,862	4,094,545	1,617,128	4.4	61.41	3.66	2.17	0.10	5.48	0.00
Beebyn_Main_West_1	408	5	889,668	3,255,775	1,290,188	3.7	61.59	3.41	2.08	0.10	5.57	0.00
Beebyn_Main_West_1	396	6	858,227	2,578,492	1,021,563	3.0	61.6	3.4	2.02	0.10	5.74	0.00
Beebyn_Main_West_1	384	6	779,842	1,940,292	772,728	2.5	61.66	3.31	1.92	0.10	5.76	0.00
Beebyn_Main_West_1	372	6	624,495	1,342,772	531,827	2.2	62.08	3.31	1.89	0.10	5.42	0.00
Beebyn_Main_West_1	360	6	369,119	725,757	290,835	2.0	62.09	3.51	1.81	0.09	5.15	0.00
Beebyn_Main_West_1	348	6	259,940	322,774	119,680	1.2	62.14	3.92	1.75	0.09	4.71	0.00
Beebyn_Main_West_1	336	Un-Scheduled	183,736	119,907	39,473	0.7	62.9	4.16	1.57	0.08	4.13	0.00
Beebyn_Main_West_1	324	Un-Scheduled	64,756	25,375	8,124	0.4	62.75	4.62	1.39	0.08	3.85	0.00
Beebyn_Main_West_2	576	2		192	68							
Beebyn_Main_West_2	564	2	454	190,083	69,880	418.4	59.07	5.95	2.13	0.08	6.68	0.02
Beebyn_Main_West_2	552	2	47,841	773,398	296,342	16.2	58.8	6.33	2.08	0.09	6.68	0.02
Beebyn_Main_West_2	540	3	120,347	1,499,333	586,641	12.5	58.93	5.68	2.3	0.10	7.09	0.03
Beebyn_Main_West_2	528	3	253,045	3,046,457	1,191,538	12.0	58.86	5.74	2.2	0.11	7.24	0.03
Beebyn_Main_West_2	516	4	301,196	4,615,260	1,756,688	15.3	59.1	5.67	2.04	0.10	7.05	0.02
Beebyn_Main_West_2	504	4	259,251	4,550,491	1,733,968	17.6	58.96	5.93	1.98	0.10	6.96	0.02
Beebyn_Main_West_2	492	4	215,600	3,837,471	1,466,362	17.8	58.66	6.06	2	0.11	7.35	0.01
Beebyn_Main_West_2	480	4	235,418	3,063,111	1,181,827	13.0	58.37	5.88	2.02	0.11	7.99	0.01
Beebyn_Main_West_2	468	4	253,377	2,349,187	912,174	9.3	58.4	5.62	2	0.11	8.29	0.01
Beebyn_Main_West_2	456	4	271,304	1,742,855	665,967	6.4	59.16	4.88	1.77	0.11	8.12	0.01
Beebyn_Main_West_2	444	5	313,633	1,243,800	463,713	4.0	59.45	4.93	1.58	0.11	7.78	0.00
Beebyn_Main_West_2	432	5	333,494	825,229	293,473	2.5	59.52	5.06	1.51	0.12	7.50	0.00
Beebyn_Main_West_2	420	5	316,394	482,211	156,595	1.5	59.48	5.11	1.41	0.12	7.62	0.00
Beebyn_Main_West_2	408	5	160,728	137,816	42,466	0.9	59.97	4.56	1.33	0.13	7.72	0.01
Beebyn_Pod_East	576	2	235	46,096	16,459	195.9	57.37	7.44	2.38	0.13	7.21	0.02
Beebyn_Pod_East	564	2	58,290	575,325	221,917	9.9	57.62	7.57	2.38	0.12	6.98	0.02
Beebyn_Pod_East	552	2	74,145	1,188,146	462,607	16.0	57.72	7.58	2.31	0.11	6.88	0.02
Beebyn_Pod_East	540	4	74,267	1,340,722	543,207	18.1	57.94	7.44	2.25	0.11	6.92	0.02
Beebyn_Pod_East	528	4	74,726	1,030,580	423,451	13.8	58.12	7.25	2.24	0.11	7.11	0.02
Beebyn_Pod_East	516	4	64,723	647,593	264,140	10.0	58.37	7.08	2.15	0.12	6.89	0.02
Beebyn_Pod_East	504	4	47,253	354,232	145,905	7.5	58.14	7.26	2.2	0.12	6.75	0.02
Beebyn_Pod_East	492	4	22,940	164,541	65,009	7.2	58.48	6.46	2.24	0.12	6.66	0.01
Beebyn_Pod_East	480	4	11,508	52,696	19,924	4.6	58.41	6.79	2.16	0.11	6.25	0.01

PIT	Bench	Period	Ore Tonnes	Waste Tonnes	Waste BCM	SR	FE%	SIO2%	AL2O3%	P%	LOI%	S%
Beebyn_Pod_Central	540	2	25,585	570,604	193,798	22.3	58.1	7	2.52	0.12	6.80	0.02
Beebyn_Pod_Central	528	2	130,140	1,634,814	561,374	12.6	58.89	6.77	2.25	0.09	6.46	0.02
Beebyn_Pod_Central	516	2	157,221	1,737,471	597,674	11.1	59.2	6.79	2.07	0.09	6.09	0.02
Beebyn_Pod_Central	504	3	162,997	1,207,438	415,060	7.4	60.46	5.31	2.03	0.10	5.99	0.01
Beebyn_Pod_Central	492	3	158,525	754,026	257,705	4.8	61.44	4.21	2.06	0.11	5.58	0.01
Beebyn_Pod_Central	480	3	144,717	379,792	128,580	2.6	60.8	4.49	2.13	0.11	5.74	0.01
Beebyn_Pod_Central	468	3	109,810	104,498	34,133	1.0	60.75	4.59	2.23	0.11	5.51	0.01
Beebyn_Pod_Central	456	4	38,924	19,359	6,188	0.5	61.12	4.51	2.29	0.11	5.24	0.01
Beebyn_Pod_West	552	2	792	55,833	20,241	70.5	57.68	7.85	2.75	0.06	6.65	0.03
Beebyn_Pod_West	540	2	79,406	869,621	330,178	11.0	57.63	5.77	2.63	0.10	7.75	0.02
Beebyn_Pod_West	528	2	228,973	2,497,523	966,727	10.9	57.97	5.91	2.65	0.11	7.65	0.02
Beebyn_Pod_West	516	2	347,445	3,553,589	1,342,543	10.2	58.49	5.61	2.59	0.11	7.60	0.02
Beebyn_Pod_West	504	3	341,458	2,513,296	970,633	7.4	58.49	5.74	2.61	0.12	7.58	0.01
Beebyn_Pod_West	492	3	309,912	1,691,170	642,929	5.5	58.59	5.78	2.43	0.12	7.48	0.01
Beebyn_Pod_West	480	3	273,923	1,009,254	358,934	3.7	58.91	5.66	2.2	0.13	7.40	0.01
Beebyn_Pod_West	468	3	210,372	389,451	123,920	1.9	59.17	5.22	2.1	0.14	7.24	0.00
Beebyn_Pod_West	456	3	130,214	78,757	21,335	0.6	59.07	5.2	2.23	0.14	7.21	0.00
Beebyn_Pod_West	444	4	32,470	13,873	3,604	0.4	59.44	4.95	2.28	0.13	7.02	0.00
Madoonga_Stage_1	564	1	158,294	519,150	179,806	3.3	57.48	6.92	2.04	0.29	8.15	0.08
Madoonga_Stage_1	552	1s	427,556	1,018,920	347,560	2.4	58.81	5.79	2.3	0.08	7.05	0.07
Madoonga_Stage_1	540	1s	911,857	1,728,438	581,252	1.9	58.69	5.62	2.21	0.09	7.33	0.07
Madoonga_Stage_1	528	1s	1,184,661	3,380,818	1,151,438	2.9	58.79	5.25	2.18	0.09	7.57	0.07
Madoonga_Stage_1	516	1	1,305,352	6,616,184	2,308,488	5.1	59.23	4.89	2.07	0.09	6.96	0.06
Madoonga_Stage_1	504	1s	1,320,433	7,806,650	2,993,665	5.9	59.35	4.73	2.18	0.09	6.80	0.06
Madoonga_Stage_1	492	1	1,358,794	7,004,721	2,724,370	5.2	59.22	4.57	2.04	0.09	7.46	0.07
Madoonga_Stage_1	480	1	1,336,055	6,285,719	2,466,667	4.7	59.36	4.25	1.97	0.09	7.84	0.07
Madoonga_Stage_1	468	2	1,219,343	5,693,310	2,232,149	4.7	59.47	4.02	1.91	0.09	7.61	0.07
Madoonga_Stage_1	456	2	1,158,599	5,069,892	1,986,969	4.4	59.58	3.85	1.82	0.09	7.66	0.07
Madoonga_Stage_1	444	2	1,063,436	4,575,740	1,768,654	4.3	58.9	4.64	1.83	0.10	7.93	0.06
Madoonga_Stage_1	432	2	915,787	4,135,643	1,569,644	4.5	59.02	4.57	1.82	0.10	7.86	0.07
Madoonga_Stage_1	420	2	874,655	3,601,228	1,369,309	4.1	59.1	4.66	1.8	0.10	7.91	0.08
Madoonga_Stage_1	408	2	784,218	3,122,647	1,183,507	4.0	59.52	4.55	1.73	0.11	7.61	0.09
Madoonga_Stage_1	396	2	906,858	2,495,099	938,749	2.8	59.21	5.22	1.57	0.10	7.37	0.09
Madoonga_Stage_1	384	2	829,321	2,121,681	773,396	2.6	59.55	5.13	1.49	0.10	7.10	0.09
Madoonga_Stage_1	372	3	716,276	1,817,305	642,413	2.5	59.71	4.91	1.35	0.10	7.34	0.10
Madoonga_Stage_1	360	3	704,112	1,463,573	504,204	2.1	59.6	5.01	1.27	0.10	7.65	0.11
Madoonga_Stage_1	348	3	636,314	1,128,305	383,046	1.8	59.67	5.25	1.22	0.10	7.23	0.12
Madoonga_Stage_1	336	3	611,845	711,021	244,988	1.2	59.63	5.69	1.19	0.10	7.00	0.13
Madoonga_Stage_1	324	3	443,701	548,922	189,097	1.2	59.61	5.58	1.29	0.10	6.97	0.12
Madoonga_Stage_1	312	3	244,073	432,205	149,997	1.8	59.6	5.64	1.24	0.10	6.76	0.11
Madoonga_Stage_1	300	3	109,788	204,364	71,160	1.9	58.88	6.61	1.22	0.11	7.87	0.12
Madoonga_Stage_2	528	3	15,462	722,858	257,209	46.8	55.41	7.09	2.93	0.03	9.63	0.10
Madoonga_Stage_2	516	3	165,891	4,414,413	1,562,325	26.6	55.55	6.79	2.87	0.04	9.60	0.08
Madoonga_Stage_2	504	3	420,383	6,849,880	2,435,275	16.3	55.79	6.8	2.87	0.04	9.51	0.09
Madoonga_Stage_2	492	3	832,375	5,857,221	2,306,782	7.0	57.14	5.35	2.67	0.05	9.43	0.08
Madoonga_Stage_2	480	3	1,034,018	4,868,026	1,942,909	4.7	57.87	4.68	2.53	0.05	9.31	0.07
Madoonga_Stage_2	468	3	1,131,377	4,056,746	1,622,665	3.6	58.06	4.77	2.41	0.05	9.01	0.07
Madoonga_Stage_2	456	4	1,116,995	3,419,998	1,361,116	3.1	58.11	4.95	2.29	0.06	8.77	0.06
Madoonga_Stage_2	444	6	1,089,130	2,810,135	1,111,365	2.6	57.95	5.46	2.29	0.06	8.49	0.07
Madoonga_Stage_2	432	6	974,314	2,308,065	897,002	2.4	57.66	5.75	2.35	0.06	8.54	0.07
Madoonga_Stage_2	420	Un-Scheduled	761,664	1,871,294	717,204	2.5	57.33	6.01	2.4	0.06	8.46	0.08
Madoonga_Stage_2	408	Un-Scheduled	533,777	1,324,742	500,743	2.5	57.36	5.96	2.53	0.06	8.42	0.08
Madoonga_Stage_2	396	Un-Scheduled	267,174	672,588	247,154	2.5	58.21	5.43	2.03	0.05	8.43	0.08
Madoonga_Stage_2	384	Un-Scheduled	179,286	308,590	111,970	1.7	58.15	5.85	2.16	0.04	8.24	0.09
Madoonga_Stage_2	372	Un-Scheduled	70,004	99,226	36,347	1.4	57.3	6.88	2.29	0.04	8.04	0.12
Madoonga_Stage_2	360	Un-Scheduled	42,966	26,110	9,632	0.6	57.89	5.36	2.19	0.03	8.13	0.14
Madoonga_Stage_3	528	2s	56	14,026	4,873	250.5	55.96	5.85	3.12	0.05	9.73	0.08
Madoonga_Stage_3	516	2	14,504	448,620	159,544	30.9	56.08	5.95	2.93	0.03	9.61	0.08
Madoonga_Stage_3	504	2	128,548	2,487,829	881,479	19.4	56.02	6.27	2.61	0.03	9.69	0.06
Madoonga_Stage_3	492	2	423,966	5,371,952	1,951,378	12.7	56.24	6.36	2.48	0.03	9.80	0.07
Madoonga_Stage_3	480	2	630,931	7,031,634	2,640,887	11.1	56.28	6.39	2.55	0.04	9.70	0.06
Madoonga_Stage_3	468	2	768,936	5,538,211	2,205,325	7.2	56.58	5.93	2.65	0.04	9.75	0.05
Madoonga_Stage_3	456	2	839,378	4,408,008	1,795,754	5.3	56.49	6.05	2.73	0.05	9.61	0.06
Madoonga_Stage_3	444	3	994,509	3,309,996	1,372,249	3.3	57.1	5.61	2.49	0.05	9.66	0.06
Madoonga_Stage_3	432	3	1,012,755	2,485,103	1,027,505	2.5	58.01	4.56	2.12	0.05	9.66	0.07
Madoonga_Stage_3	420	3	901,929	1,825,209	746,425	2.0	58.06	4.66	2.16	0.05	9.45	0.08
Madoonga_Stage_3	408	4	828,730	1,224,725	493,169	1.5	57.69	5.08	2.24	0.05	9.21	0.11
Madoonga_Stage_3	396	4	722,582	839,205	328,788	1.2	57.27	5.59	2.14	0.05	9.20	0.11
Madoonga_Stage_3	384	4	527,329	497,178	193,159	0.9	57.36	5.71	1.94	0.05	9.30	0.13
Madoonga_Stage_3	372	4	305,008	222,448	86,557	0.7	56.89	5.93	2	0.05	9.66	0.13
Madoonga_Stage_3	360	Un-Scheduled	99,151	47,735	18,528	0.5	57.03	5.6	2.31	0.05	9.52	0.12

Note: Period '1s' implies that material is mined in Period 1 and sent to stockpile. This stockpile is never retrieved so does not form a part of the inventory. Similarly '2s'.

Appendix 2: Vertical Advance

Pit	1	2	3	4	5	6	1s	2s	Un-Scheduled	Grand Total
Beebyn_Main_Central										
Max of Bench RL				528	420				408	528
Min of Bench RL				432	420				384	384
Beebyn_Main_East										
Max of Bench RL	540	516	456	384						540
Min of Bench RL	528	468	396	324						324
Beebyn_Main_West_1										
Max of Bench RL				552	468	396			336	552
Min of Bench RL				480	408	348			324	324
Beebyn_Main_West_2										
Max of Bench RL		576	540	516	444					576
Min of Bench RL		552	528	456	408					408
Beebyn_Pod_Central										
Max of Bench RL		540	504	456						540
Min of Bench RL		516	468	456						456
Beebyn_Pod_East										
Max of Bench RL		576		540						576
Min of Bench RL		552		480						480
Beebyn_Pod_West										
Max of Bench RL		552	504	444						552
Min of Bench RL		516	456	444						444
Madoonga_Stage_1										
Max of Bench RL	564	468	372				552			564
Min of Bench RL	480	384	300				504			300
Madoonga_Stage_2										
Max of Bench RL			528	456		444			420	528
Min of Bench RL			468	456		432			360	360
Madoonga_Stage_3										
Max of Bench RL		516	444	408				528	360	528
Min of Bench RL		456	420	372				528	360	360

1	2	3	4	5	6
			8	0	
1	4	5	5		
			6	5	4
	2	1	5	3	
	2	3	0		
	2		5		
	3	4	0		
7	7	6			
		5	0		
	5	2	3		

Note: Period '1s' implies material is mined in Period 1 and sent to stockpile. This stockpile is never retrieved so does not form a part of inventory. Similarly '2s'.

Appendix 3: COMBO Variable Codes

COMBO	Fe Range	Silica Range	Alumina Range
0		$8.3 < SiO_2$	
1	Fe < 50	$SiO_2 <= 8.3$	
2	55 <= Fe < 60	$0 <= SiO_2 < 3.5$	$0 <= Al_2O_3 < 1.7$
3			$1.7 <= Al_2O_3 < 2.3$
4			$2.3 <= Al_2O_3 <= 100$
5		$3.5 <= SiO_2 < 5.5$	$0 <= Al_2O_3 < 1.7$
6			$1.7 <= Al_2O_3 < 2.3$
7			$2.3 <= Al_2O_3 <= 100$
8		$5.5 <= SiO_2 <= 8.3$	$0 <= Al_2O_3 < 1.7$
9			$1.7 <= Al_2O_3 < 2.3$
10			$2.3 <= Al_2O_3 <= 100$
11	60 <= Fe < 67	$0 <= SiO_2 < 3.5$	$0 <= Al_2O_3 < 1.7$
12			$1.7 <= Al_2O_3 < 2.3$
13			$2.3 <= Al_2O_3 <= 100$
14		$3.5 <= SiO_2 < 5.5$	$0 <= Al_2O_3 < 1.7$
15			$1.7 <= Al_2O_3 < 2.3$
16			$2.3 <= Al_2O_3 <= 100$
17		$5.5 <= SiO_2 <= 8.3$	$0 <= Al_2O_3 < 1.7$
18			$1.7 <= Al_2O_3 < 2.3$
19			$2.3 <= Al_2O_3 <= 100$
20	67 <= Fe <= 100	$0 <= SiO_2 < 3.5$	$0 <= Al_2O_3 < 1.7$
21			$1.7 <= Al_2O_3 < 2.3$
22			$2.3 <= Al_2O_3 <= 100$
23		$3.5 <= SiO_2 < 5.5$	$0 <= Al_2O_3 < 1.7$
24			$1.7 <= Al_2O_3 < 2.3$
25			$2.3 <= Al_2O_3 <= 100$
26		$5.5 <= SiO_2 <= 8.3$	$0 <= Al_2O_3 < 1.7$
27			$1.7 <= Al_2O_3 < 2.3$
28			$2.3 <= Al_2O_3 <= 100$
29	50 <= Fe < 55	$0 <= SiO_2 < 3.5$	$0 <= Al_2O_3 < 1.7$
30			$1.7 <= Al_2O_3 < 2.3$
31			$2.3 <= Al_2O_3 <= 100$
32		$3.5 <= SiO_2 < 5.5$	$0 <= Al_2O_3 < 1.7$
33			$1.7 <= Al_2O_3 < 2.3$
34			$2.3 <= Al_2O_3 <= 100$
35		$5.5 <= SiO_2 <= 8.3$	$0 <= Al_2O_3 < 1.7$
36			$1.7 <= Al_2O_3 < 2.3$
37			$2.3 <= Al_2O_3 <= 100$