ENTERPRISE OPTIMIZATION

Report

for the

Nordic Iron Ore™

Blötberget Mine

by:

Whittle Consulting

Integrated Strategic Planning for the Mining Industry

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Report History		
Version	Description	Date
1.2	First Draft	28 October 2020
3.1	Client revisions, other additions	11 November 2020
4.0	Chart corrections	13 November 2020

EXECUTIVE SUMMARY

Whittle Consulting Proprietary Limited (WCPL) has been retained to provide an Enterprise Optimization Study for Nordic Iron Ore's (NIO) Blötberget Project, near Ludvika, Sweden. This report details the assumptions and findings of this study.

The MRE2017 model was used for this study. An activity-based cost (ABC) model was generated for the study based on the 2019 DFS results. WCPL has developed Pre- and (Post-tax) NPVs at an 8% discount rate. The Pre-tax NPV is an operational discounted net value based on revenue minus costs and no working capital is included in this calculation.

BASE CASE

The data from the 2019 Golder Feasibility Study was reviewed in detail. After detailed deconstruction of the Golder Financial Model Basis of Estimate (BoE) approach, WCPL finalised an Activity-Based Costing (ABC) model leveraging the detail in the BoE model.

The Run 12 series uses the Mine Model 2d detailed metal recoveries. The Base Case Pre-tax (Post-Tax) NPV8 for **Run 12B** for the project is $113M ($73.0M), with an IRR of 15.7% (13.3%).

MINING METHOD TRADE OFF STUDY

A mining method trade-off study was completed by Mining Plus, directed from the UK office in Bristol, U.K., with the work completed in Toronto, Ontario, Canada. Benchmark costs were generated for three mining methods- Post and Pillar Cut and Fill (PPCF, the current planned method), Long Hole Open Stoping (LHOS), and Avoca (a variant of Long Hole Open Stoping better suited for lower-angle ore zones). These costs indicated that PPCF was the most expensive method.

The PPCF mining method was used for the advancement of the study for several reasons. First, the costs from the trade-off study were high level, and NIO wished to maintain a cost estimate level similar to the Feasibility Study. Second, a different development network would be required to appropriately model the LHOS and Avoca mining methods which are different enough that the PPCF design was not adequate, and there was no budget for new design work. Finally, NIO indicated that local cost estimates were much closer in terms of unit costs per mining method, which were not captured in the benchmarked costs developed by Mining Plus.

PROBER SCHEDULE-OPTIMIZED CASE

The development and stoping relationships and behaviours were reviewed and refined and were tested in an initial Prober schedule (Run 13 series) in early August. A Prober-optimized schedule using the Feasibility Study designs and parameters was generated as Run series 26, with **Run 26H** being the most recent version. The NPV8 is $129.8M ($86.1M) with an IRR of 17.0% (14.4%) which adds 14.9% (17.8%) to the NPV8 over the Prober Base case Run 12B.

MSO NET VALUE SHAPES

Mining Plus generated Mine Shape Optimizer (MSO) underground mining shapes for modeling differing cut-off grades by district. These shapes were calculated using net value, contained iron NSR minus operating costs (including pro-rata allocation of period costs), which indicates the margin per tonne of iron ore. Ultimately the value cut-offs from -$5 to +$20 in $2.50 increments were used for optimizing the net value cut-off over the life of the mine.

GA-OPTIMIZED CASES

Several genetic algorithm (GA) runs were generated for Blötberget. The GA is an ancillary optimization tool that allows for an optimization of multiple single choice cutoffs over a range of districts.

GA optimizations were generated with increasing numbers of cut-off ranges, which were then reduced as the cut-off ranges per formation were refined. The Blötberget project is currently on the 5th generation of GA optimization.

Run 40A is based on a mature GA that was the culmination of efforts to this point in the study. The net value cut-offs chosen by the GA and then scheduled in Prober are presented in Table 1.

Table 1 - Net Value Cut-offs chosen for Run 40A

NIO1 Nordic Iron Ore EO Project, Prober Run 040A

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MINING SUMMARY and STOPING PHYSICALS

Design Used

Design Net Value of MSO Stope presented to Prober for scheduling

		Total
Sandell Level 2	Design used	MP $7.50 NV/t
Sandell Level 3	Design used	MP $2.50 NV/t
Hugfly 2.1	Design used	MP $10.00 NV/t
Hugfly 3.1	Design used	MP $12.50 NV/t
Hugfly 3.2	Design used	MP $10.00 NV/t
Hugfly 4.1	Design used	MP $10.00 NV/t
Hugfly 4.2	Design used	MP $15.00 NV/t
Hugfly 5.1	Design used	MP $7.50 NV/t
Hugfly 5.2	Design used	MP $7.50 NV/t
Hugfly 5.3	Design used	MP $2.50 NV/t
Hugfly 6.1	Design used	MP $10.00 NV/t
Hugfly 6.2	Design used	MP $0.00 NV/t
Hugfly 6.3	Design used	MP $2.50 NV/t
Hugfly 7.1	Design used	MP $7.50 NV/t
Hugfly 8.1	Design used	MP $0.00 NV/t
Kalv 3.1	Design used	MP $7.50 NV/t
Kalv 4.1	Design used	MP $15.00 NV/t
Kalv 5.1	Design used	MP $17.50 NV/t
Kalv 6.1	Design used	MP $7.50 NV/t
Kalv 7.1	Design used	MP $0.00 NV/t

OPERATIONAL REFINEMENTS

As the project matured, the reporting for the Prober runs deepened with a development schedule table, dynamic working capital/depreciation/additional equipment and other refinements to the tabular and dashboard reporting. These include various aggregations of development, a power model for crushing (hematite versus magnetite) and grinding (Kalvgruvan versus other formations).

Other significant changes at this stage include delaying Kalvgruvan to allow all development to be completed, maximum 80% magnetite in ore feed allowed, quarterly resolution on development and production, and development allowed to accelerate from the original DFS MineSched advancement rates at a district by district level.

These changes are considered critical and have been reviewed by NIO and MP.

Run 40A, using the GA cut-offs, Prober scheduling, and the base case parameters with refinements, has an NPV8 of $146.9M ($100.1M) and an IRR of 19.4% (16.2%). The cumulative NPV improvement over the Base Case is 30.1% (37.1%), adding $33.9M ($27.1M) to the NPV8. A key takeaway from the runs completed to this point is the focus in the medium term on deeper, high Kalvgruvan magnetite ore to maximize revenue.

POWER MODEL

A power model for crushing and grinding was constructed. The power model uses the geological formation for crushing power, and the mineral composition for grinding power. This model is used for costing in all runs after Run 41 inclusive and is used as a constraint in Runs 41O/48F/62A and 63A. **Run 63A**, which also has a coarse concentrate option available, has an NPV8 of $172.1M ($186.1M).

THEORY OF CONSTRAINTS

Initially the optimization model was limited by conveyed or processed tonnes. A power limit was applied, which by itself had little effect on NPV, but when combined with an option for coarse concentrate, eliminating the regrind for some or all of the product, the power model balances the crushing and grinding power by eliminating the regrind at times. It should be noted that the crushing power was increased 10% for the power optimized cases in Runs 48F, 62A, and **Run 63A**.

SCENARIO RESULTS

A suite of scenarios was run. Using a front-end loader (FEL) at the rail terminal adds value due to reduced investment cost, but this may not be the best option if further resource is found. Truck haulage to surface does not improve NPV as the lower operating cost for the conveyor more than overcomes the capital cost. Increased production rates add value, with the capital scaled using the six tenths rule. Further work would be required to understand if differing production rates were actually optimum if capitalized more robustly.

An option to bypass the regrind circuit to produce a coarse concentrate at a reduced price was developed. This case is interesting as a power-constrained model with this option available will balance the power consumption between the crushing and grinding circuits, and this allows some material to be processed sooner at a lower price, slightly increased plant capacity. This methodology adds value and should be considered further.

An additional 5.0Mt of material of moderate iron grade (simulating recovery of historical resource) was made available in Y1 after 1km of development and adds value. This material comes into production throughout the mine life, although in most cases at the DFS plant sizing it was only utilized at the end of the mine life to augment feed from the lower districts. As a rule, additional economic material adds value.

Increased mine development rates added value due to primarily accessing Kalvgruvan 4-1 a few quarters earlier in Y1. Run 50D improved NPV8 over the GA schedule optimized case Run 41G by 7.8%. Operational efficiency is always beneficial, so improving development rates will be worthwhile in terms of labor and equipment costs as well as improving NPV.

Contractor mining was modeled. This adds value by reducing the mine capital costs. These costs are on a different basis than was developed for the owner fleet, which used tonne-kilometers as an ABC driver in the mine. The quoted mine contractor costs are flat haulage rates ($/tonne) which may not be relevant over the life of the mine. Options for haul to surface and haul to crusher were generated.

After generating a comparable base run for the mine costs, the contractor costs only added value for a case with conveyor haulage, where the contractor is mining and hauling to the underground crusher/conveyor system. Further work is required to establish the long-term veracity of the mine contractor quote.

An “All-in” case was developed, Run 61A, with a 4.0Mtpa plant, 5.0Mt of additional resource, and contractor mining and haul to crusher/conveyor. This is the most aggressive and highest value case within the DFS iron price case used thus far. Run 61A has an NPV8 of $255.8M ($186.1M).

An “Upside” case was generated. This case was as 61A with the addition of accelerated development and the reduced rail costs, using an FEL instead of an auto loader. This case is Run 66A, which has an NPV8 of $264.8M ($194.7M).

A series of price cases were developed, and a linear increase in NPV is seen as the prices for magnetite and hematite are increased. As would be expected, the base case assumptions with the Upside process has the highest NPV in the series.

There were several economic exercises completed, including selected 6% discount rate schedules and discounted breakeven pricing cases.

OBSERVATIONS AND RECOMMENDATIONS

The planning for Blötberget has been thorough and well done. Some inconsistencies were found in the planning documents supporting the FS, but these differences are understood and reconciled.

The Prober/Genetic Algorithm (GA) cut-off value cases and mining sequence variations add value to the project.

A power-optimized model combined with the option to produce a coarse concentrate product (no regrind), adds value, and may add plant capacity at little or no capital cost.

The conveyor haulage/hoisting solution, with the assumptions modeled here, adds value.

Any additional resource available will add value and could be scheduled nearly any time depending on tonnes and grade estimates.

Understanding the alternative mining methods in terms of cost and development requirements is important.

Mining contractor rates may add value if the long-term costs are properly portrayed.

A better understanding of the mine contractor quotes is important, and these could be generated for the alternative mining methods as well.

Figure 1 and Table 2 indicate summary metrics and value contributions for the study.

Figure 1 – Value Contributions

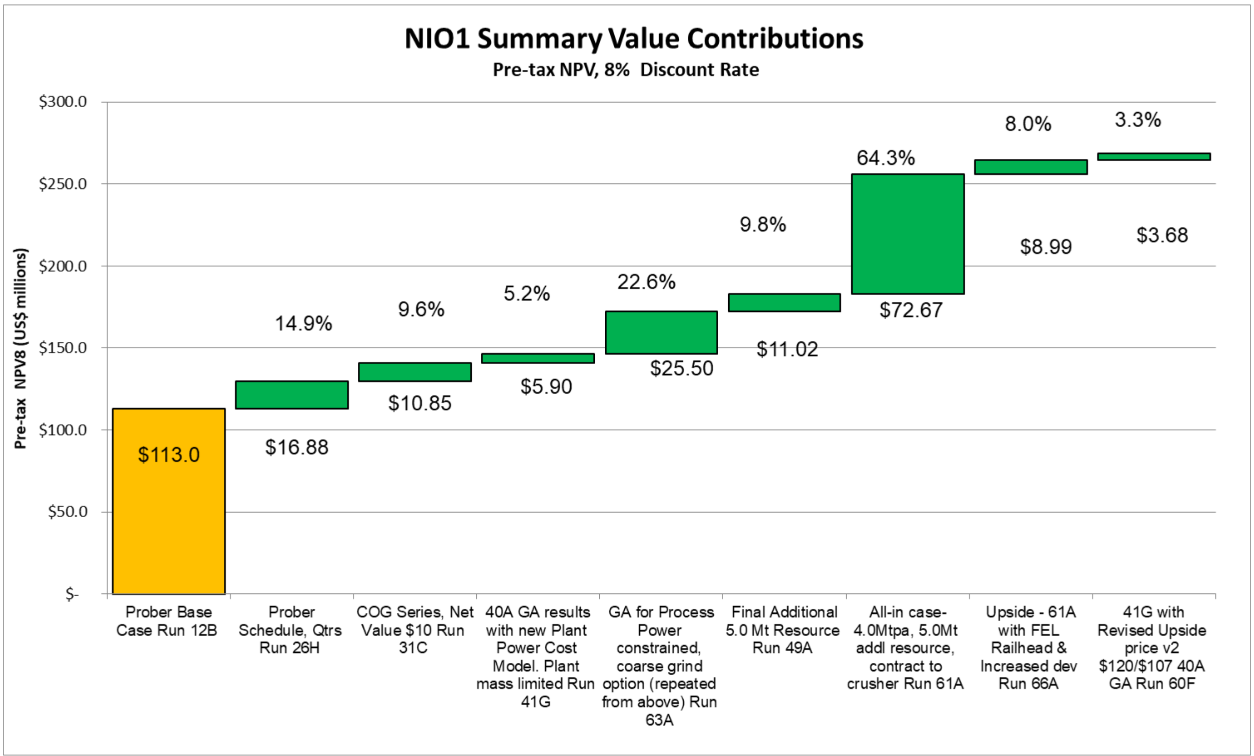

Table 2 – Case Comparison

NIO1 - Blötberget Whittle Consulting
Run Summary

Case	Run#	Free Cash Flow (M$)	LOM Pre-tax NPV8 (M$)	Pre-tax IRR	LOM Post-Tax NPV8 (M$)	Post-tax IRR	Pre-Production Capital (M$)	Total Capital (M$)	Total Processing Capital (M$)	Total Mined (dry Mmt)	Total Processed (Mmt)	Total Tailings to TMF (Mm3) (1.56t/m3)
Client Case												
REVISED Golder FinMod FinMod 080720, Mine Model 2d	Base	$ 295.7	$ 105.9	14.9%	$ 65.2	12.6%		$ 322.41	$ 117.39	37.79	34.06	6.11
Base Case												
Base Case - Includes egress and vent raises, MM2d metal recovery and extra development	12B	$ 299.8	$ 113.0	15.7%	$ 73.0	13.3%	$ 255.2	$ 327.3	$ 126.00	37.80	33.92	6.10
Prober Schedule												
Prober Schedule, Qtrs	26H	$ 310.4	$ 129.8	17.0%	$ 86.1	14.4%	$ 251.3	$ 336.2	$ 126.00	37.80	33.92	6.07
Net Value Cut-off												
COG Series, Net Value $10	31C	$ 316.7	$ 140.7	18.1%	$ 94.9	15.3%	$ 251.2	$ 334.0	$ 125.66	34.67	31.02	5.33
Genetic Algorithm Net Value Cut-offs												
GA, Power, other refinements	40A_GA00	$ 308.1	$ 146.9	19.4%	$ 100.1	16.2%	$ 249.7	$ 332.2	$ 125.66	36.59	32.89	5.77
Optimized cases												
40A GA results with new Plant Power Cost Model. Plant mass limited	41G	$ 304.7	$ 146.6	19.2%	$ 97.9	16.0%	$ 249.7	$ 329.5	$ 125.66	36.59	32.89	5.81
Coarse con, power limited												
41G, GA for Process Power constrained, coarse grind option	63A	$ 338.4	$ 172.1	21.2%	$ 119.6	17.7%	$ 253.6	$ 339.5	$ 125.33	37.37	33.59	5.85
Additional Production, Resource												
As 41G, Final Additional 5.0 Mt Resource	49A	$ 378.1	$ 183.1	20.7%	$ 126.9	17.4%	$ 248.9	$ 332.3	$ 126.00	40.06	36.15	6.27
Price Cases												
Revised Upside v2 $120/$107 40A GA	60F	$ 474.8	$ 268.4	26.7%	$ 194.0	22.5%	$ 250.4	$ 328.6	$ 125.66	36.59	32.89	5.82
All-in Case												
All-in case- 4.0Mtpa, 5.0Mt additional resource, contract mining, reduced capital	61A	$ 435.8	$ 255.8	27.5%	$ 186.1	23.1%	$ 239.6	$ 355.1	$ 128.33	40.34	36.42	6.39
Upside Cases												
Upside- 4.0Mtpa, 5.0Mt additional res., contract mining, red. capital, FEL Railhead & Increased dev	66A	$ 438.4	$ 264.8	29.6%	$ 194.7	24.9%	$ 234.3	$ 344.2	$ 119.32	40.37	36.44	6.39