Appendix E6

Open Pit – Drilling and Blasting

Memo

From: Jesse Aarsen, Graham Milne, and Matthew Erickson

Date: June 27, 2012

Re: KSM – Drilling and Blasting Operations

1. Introduction

This Memo describes the drilling and blasting operations at KSM for the PFS. Drilling and blasting operations create suitable fragmentation of the rock for the loading and hauling cycles. The Mitchell pit in the KSM project will have an extremely high engineered pit wall and as such, controlled drilling and blasting must be needed to allow safe operation of the pit.

2. Drilling

Production drilling will be done with electric drills with a 15m bench height. Similar sites and a study done by Orica (refer to *Appendix A – KSM-SABREX Study*) show that a drill hole diameter of 311mm (12 ¼") should be used for the main production drilling. Smaller diesel drills (165mm – 6 ½" hole diameter) will be used to drill the highwall and buffer rows.
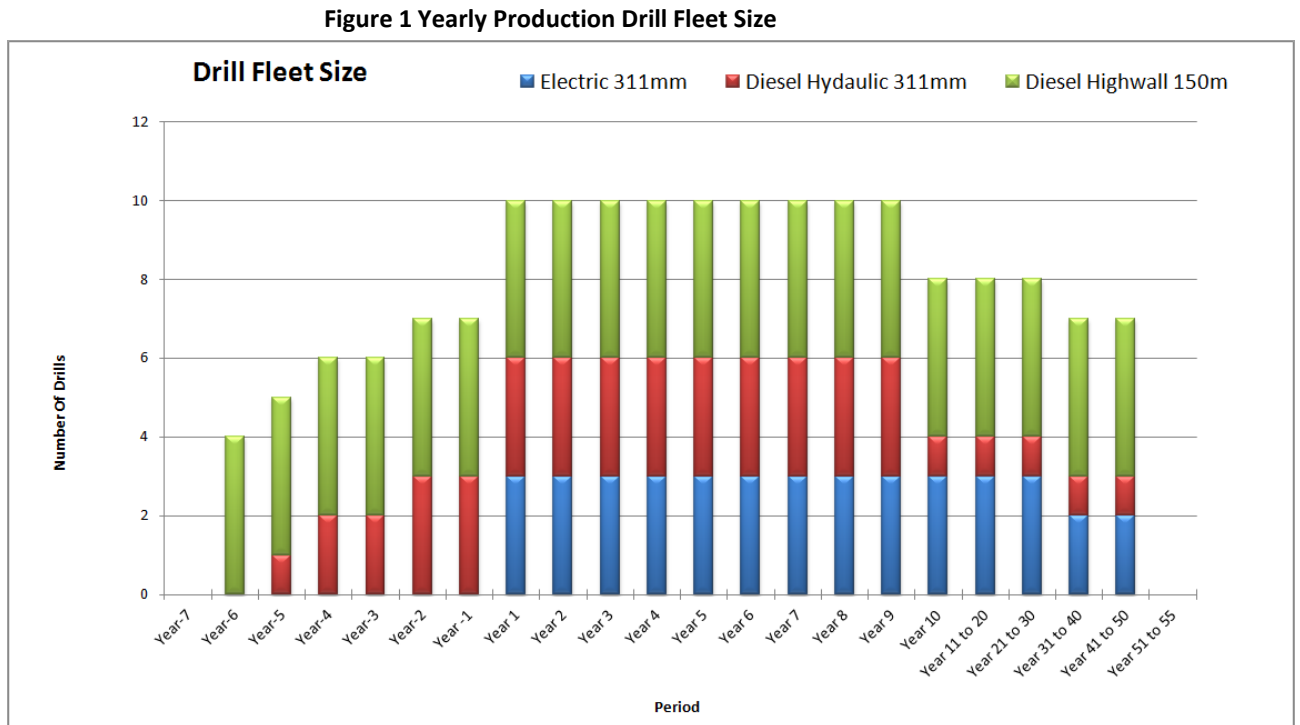
2.1 Production Drilling

Production drilling will be done with electric drills. Parameters for production drilling are shown in Table 1 below:

Table 1 Production Drill Parameters

Burden	8.5	m
Spacing	8.5	m
Hole size	311	mm
Hole size	12 1/4	"
Bench height	15	m
Sub-drill	2	m
Rock/Ore tonnes per hole	3,002	Tonnes
Penetration rate (instantaneous rate)	44	m/hr
Set-up time	2	min
Drilling time	45.3	min
Moving time	2	min
Productivity (includes set-up and moving time)	40	m/op hr

The drilling productivity excludes moving time between patterns and benches and doesn't account for operator efficiency.

Based on schedule 11b, the maximum estimated fleet size is: 3 electric 311mm, 3 diesel 311mm, and 4 diesel highwall Drills. The yearly drill requirement is shown in Figure 1 below:

Figure 1 Yearly Production Drill Fleet Size

While most production drilling will be done to a 17m depth (bench height plus sub-drill), a few of the drills in the fleet should have a 34m drilling depth minimum capability to allow for double bench drilling in special circumstances.

2.2 Highwall Drilling

The significant highwall on the North and South side of Mitchell pit require special drilling and blasting consideration. Smaller highwall drills will be needed to provide the proper blasting control to maintain highwall stability. These smaller diesel drills can also be used for development of small upper benches in each pit because of their size and flexibility.

A wall control blasting study done by Orica (shown in *Appendix B - KSM - Mitchell Pit - Wall Control PFS*) shows that the highwall and buffer holes should be sized at 6 ½" (165mm) for the best control. The highwall drills will be diesel (to allow the most flexibility of movement) and need to have angle drilling capabilities and a 36m minimum drilling depth. This will allow double bench highwall holes (pre-split holes) to be drilled. If the pre-split row is not able to be double-benched, a reduction in the berm width is produced (due to
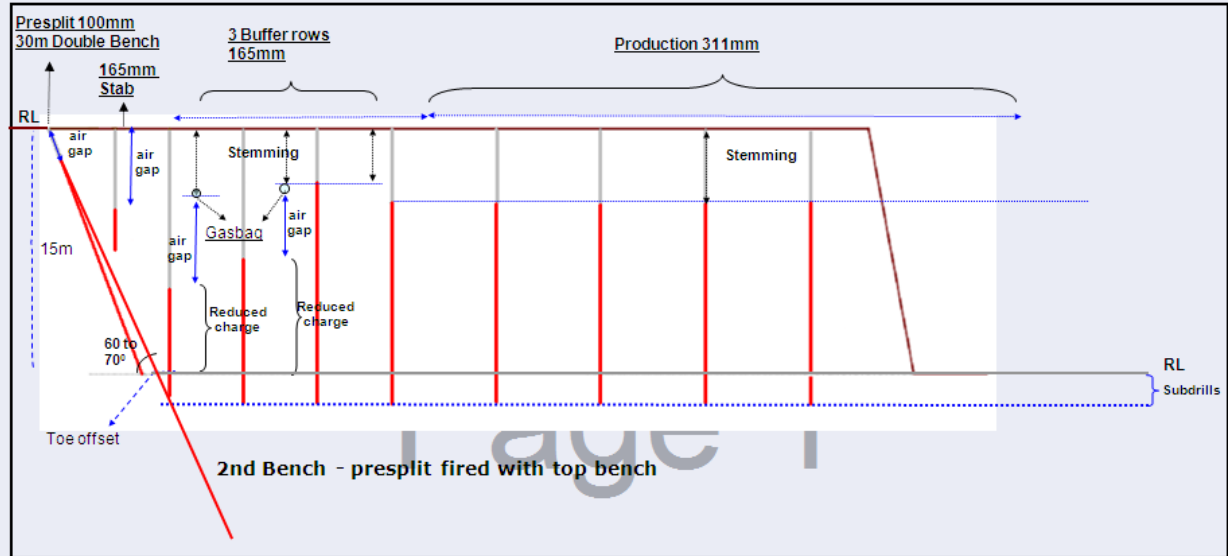
stand-off required at the toe of the upper bench if doing single bench passes). This concept is shown in Figure 2 below:

Figure 2 Single pass vs. Double pass highwall drilling
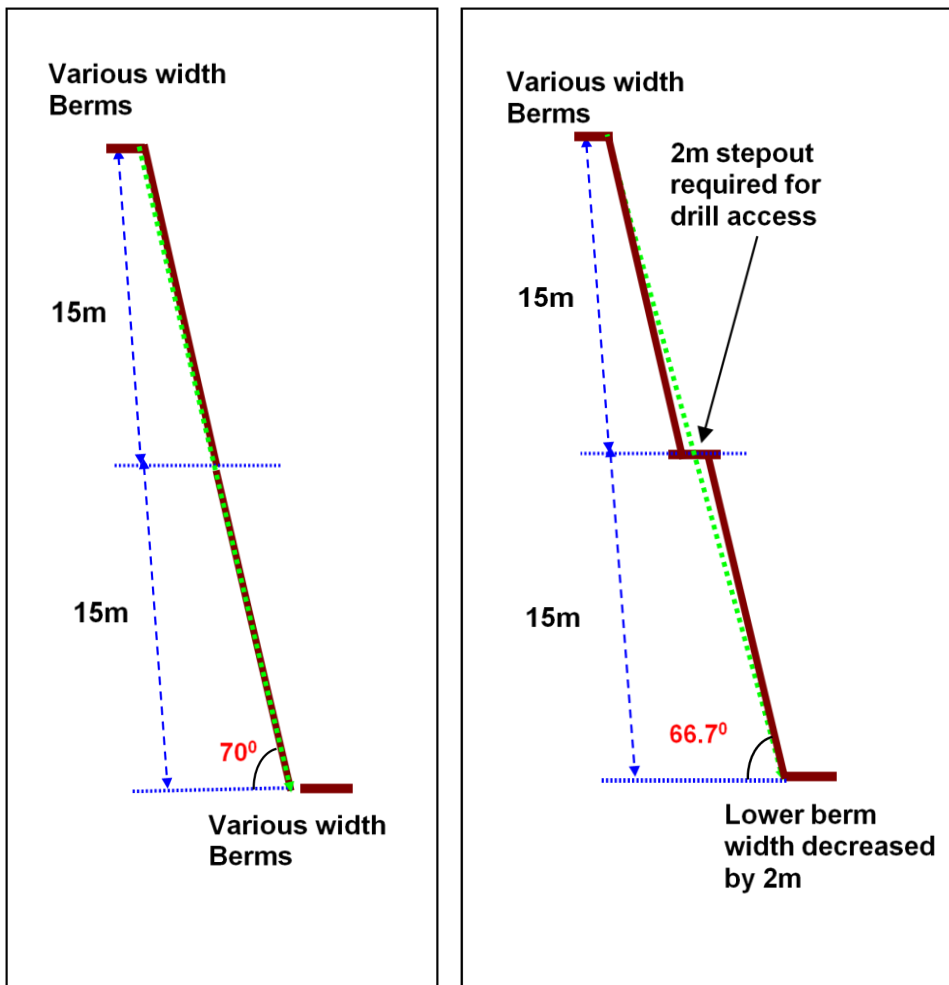
The pre-split row will be drilled all the way along the highwall at 1.8m spacing. The next row out from the highwall will be a "stab" row approximately 8m deep. The burden for the stab row will be 3.0m and the spacing will be 5.5m. Three rows of buffer holes will then be drilled at regular bench depth (15m) and sub-drill (2m) with a burden and spacing of 4.8m and 5.5m respectively. All other rows will be regular production holes. A sample cross-section of this is shown in Figure 3 below:

Figure 3 Sample Cross-section of Highwall Drilling

Type	Hole Dia.	# of rows	Length (m)	Burden (m)	Spacing (m)	Explosive	Initiation Method	kg / hole	PF
Presplit	165mm	1	32m	-	1.8	50mm packaged	Electronic	32	0.55 Kg/m2
Stab	165mm	1	~8m	3.0	5.5	Bulk emulsion/AN	Electronic	50	0.35 Kg/BCM
Buffer	165mm	3	1 bench	4.8	5.5	Bulk emulsion/AN	Electronic	200	0.5 Kg/BCM

2.3 Drilling Costs

2.3.1 Drilling Capital Costs

The approximate capital costs for a P&H 320A size drill is $5.6M. Budgetary

2.3.2 Drilling Operating Costs

The September 2012 PFS report shows drilling costs of $0.05/tonne mined. Approximate operating costs of a 311mm drill are $293/op hr.

3. Blasting

Blasting operations will be performed by mine personnel on a 7 day per week, day shift continuous basis. A contractor will be employed to supply the operations with explosives and blasting accessories as well as to deliver the product to the hole. Orica has provided a blasting summary with calculated powder factors, other blasting parameters and budgetary capital costs. This report can be found in *Appendix C - Seabridge Gold Operation with capital costs October 2009*

3.1 Powder Factor

It is important to pick an appropriate powder factor that maximizes the diggability of the material. Muck blasted with too low of a powder factor results in particles that are blocky and large and cause problems for the shovels to dig and load. This issue can cause under loaded trucks, and over the long term cause high maintenance issues for the shovels and trucks. In extreme circumstances, secondary blasting may even be required. While a low powder factor will save on drilling and blasting costs, the increased loading costs (due to lower productivity and higher wear and tear on the equipment) will offset these savings. Alternatively, using a higher powder factor will result in smaller particle sizes and better loading productivities up to a certain point where the shovels cannot load the material any faster despite the smaller particle sizes. At some point the increased drilling and blasting costs are not offset by the savings from increased productivities. A good middle point for powder factor must be chosen that results in proper fragmentation of the material that allows for the best loading productivities, balanced with reasonable drilling and blasting costs.

Orica was employed to run a SABREX (**S**cientific **A**pproach to **B**reaking **R**ocks with **E**xplosives) simulation on the rock types that were most typical and most frequently found in the Mitchell pit. SABREX simulations were run on various pattern sizes from 7.5m to 9m square equivalent and the resulting fragmentation analyzed. The results show that an 8.5m x 8.5m pattern should be used with a powder factor of 0.96kg/m^3. At an average rock density of 2.77 tonnes/m^3 this equates to a powder factor of 0.35 kg/tonne. This is similar to other large open pit projects in the KSM area. SABREX simulations show that this powder factor results in fragmentation with 80% passing 0.56m particle size. The maximum particle size expected with this powder factor is 2.01m (judged to be of no concern for shovel loading purposes).

3.2 Explosives

Explosives for the mine site will be provided by a contractor. Because of the remoteness of the operation, an explosives manufacturing facility will be built on site. Capital costs for this will total approximately $11M (a breakdown of capital costs is shown in Appendix C). The location of the manufacturing facility, magazines and ANP storage is shown in

Figure 4 below.

Figure 4 Explosives Infrastructure

The explosives manufacturing facility will produce the emulsion/ANFO blend for blasting operations. From here explosives will be delivered to the mining areas via Mobile Mixing Units (MMU). A 70/30 emulsion/ANFO blend will be used for wet holes and a 35/65 blend for dry holes. It is assumed that 50% of the material to be blasted will be "wet". The nominal plant capacity will be 80 tonnes/day with a peak production rate of 150 tonnes/day. Based on the amount of explosives stored at the facility, it must be a minimum of 960m from the magazines. A detailed layout of the explosives manufacturing facility can be found in "Appendix D - KSM_PFS_Explosives Manufacturing Facility"

Two explosives storage magazines are required for this project. One will be sized at 6' x 8' x 8' and the other at 8' x 12' x 8'. The location of these magazines is shown in

Figure 4 above.

The ANP storage area is an emergency reserve of Ammonium Nitrate Prill (ANP). Orica has recommended that the storage capacity of this area should be 400 tonnes. This amount of storage requires a minimum separation of 561m from the explosives manufacturing facility. The AN prill at the storage area, when combined with the AN in the silos (in the explosives manufacturing facility) and the AN in solution will provide 10 days of emergency service if external delivery of AN to the mine was suspended. The prill will be stored here in 1 tonne tote bags. The tote bags will be stored together in sea cans to protect the AN prill from exposure to the environment as well as any accidental release. Approximately 20-25 bags will be able to fit in a sea can. The AN prill stored here will need to be "turned" every 6 months to avoid decay.

3.3 Explosives Loading

The explosives will be delivered to the borehole via MMUs. These are bulk explosive loading trucks provided by the explosives supplier. Because of the high snowfall and extreme weather conditions that will be experienced on site, these trucks should be equipped with GPS guidance and be able to receive loading instructions for each hole from the engineering office. The explosive product that is used will be a mix of emulsion and ANFO, therefore the storage container on the truck will have a separation to store two different products. This separation will be set at the proper ratio so that both products will run out at the same time. This will minimize trips from the manufacturing facility to the blast pattern area. The capacity of the MMU is 14 tonnes.

A smaller "goat" MMU is also needed for development areas with small access roads and narrow bench working conditions. These goat trucks are similar to a logging skidder and are so named because of their high maneuverability. The goat truck MMU will be used at the start of each incremental phase in Mitchell pit and the first few benches of Kerr and Sulphurets pit.

Loading of the explosive product is done at the bottom of each hole. A column charge of 11m is needed to provide the appropriate powder factor recommended by Orica. Crushed rock (stemming) will be placed on top of the explosives in the hole to reduce fly-rock and contain the explosive force from the blast into the rock mass. Crush will be delivered to each blast pattern with a haul truck and dumped at the edge of the pattern. A small loader with a side-dump bucket will tram the crush to the boreholes as needed.

The extreme snow that will be experienced at site may inhibit loading of patterns for a period of time and cause a large snow build-up. If a blast pattern is unable to be fully loaded, the holes that are already loaded will be tied in and blasted before snow

accumulation gets too high to find the holes again or the time delay is too long and the product decays in the hole.

3.4 Blasting Operations

The blasting crew will be provided by the mine and will be a daytime only shift, 7 days per week. Based on existing mines of similar size, previous experience and the layout of the project, it is estimated that a crew size of 8 people will be needed. The blasting crew is responsible for setting up the perimeter of the blast area and maintaining proper clearance and access to the blast pattern. They will also prep the blast holes with boosters and det cord and help guide and direct the explosives truck. Once the holes are loaded they will stem the holes, tie in the pattern and detonate the blast.

3.4.1 Production Blasting

Orica's recommendations show that production blast holes will be spaced on an 8.5m square equivalent pattern with a 2m sub-drill for each hole. The sub-drill is needed to eliminate wedges of hard, un-blasted rock in the floor of the bench below. Table 2 below shows the parameters for a regular production blast.

Table 2 Production Blasting Parameters

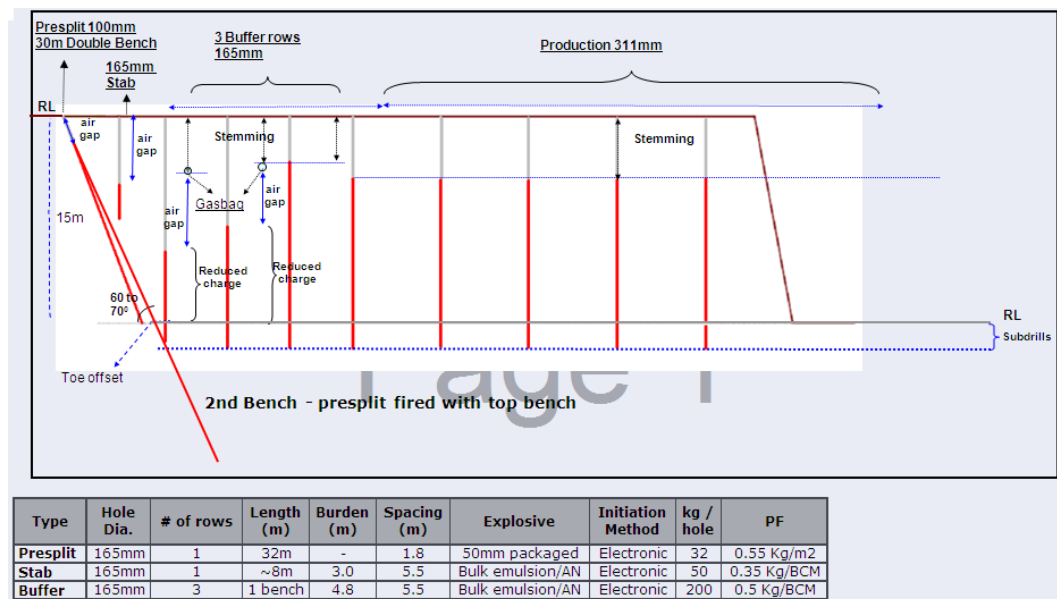|		
Burden	8.5	m
Spacing	8.5	m
Hole size	311	mm
Hole size	12 1/4	"
Bench height	15	m
Sub-drill	2	m
Collar	6	m
Loaded Column	11	m
Powder Factor	**0.96**	**kg/m^3**
Powder Factor	**0.35**	**kg/t**
Explosives in hole density	1.25	g/cc
Rock/Ore tonnes per hole	3,002	tonnes
In-hole explosives	95.0	kg/m
Explosive charge/hole	1,045	kg

3.4.2 Highwall blasting

Controlled blasting will need to be done on the final highwalls in the pit to maintain proper wall control. The precise blasting that is required for best wall control means that electronic detonation must be used.

165mm pre-split holes will be drilled at an angle to match the designed bench face angle (approximately 60^0 to 70^0). These holes should be drilled two benches deep to avoid a step-out on the intermediate bench. The pre-split holes will be loaded

with a 50mm pre-split product. This matches the 165mm pre-split holes and the product will be internally traced with detonating cord. The stab and buffer rows will be loaded with regular emulsion/ANFO mix. Stab holes will not have any stemming and the first two rows of buffer holes will have an air gap between the explosive and the stemming. A sample cross-section with the loading parameters is shown in Figure 5 below:

Figure 5 Sample cross-section of highwall blasting

Type	Hole Dia.	# of rows	Length (m)	Burden (m)	Spacing (m)	Explosive	Initiation Method	kg / hole	PF
Presplit	165mm	1	32m	-	1.8	50mm packaged	Electronic	32	0.55 Kg/m2
Stab	165mm	1	~8m	3.0	5.5	Bulk emulsion/AN	Electronic	50	0.35 Kg/BCM
Buffer	165mm	3	1 bench	4.8	5.5	Bulk emulsion/AN	Electronic	200	0.5 Kg/BCM

Further details of the highwall blasting can be found in *Appendix E - KSM project PFS wall control*

3.4.3 Cast Blasting

Cast blasting involves loading a blast pattern with a larger amount of explosives and using a type of explosive that has more of a "heaving" power than a "breaking" power. It may be appropriate in certain pioneering circumstances where there is a large open face, steep topography below the blast (to allow blasted material to move down slope) and there is a thin burden of material to be moved. Care must be maintained when doing a cast blast to make sure that there is no down slope risk to working areas. If the above criteria are satisfied, a cast

blast can be designed to move as much material as far down slope as possible to reduce the material movement costs. Remaining material on the bench can be pushed over the edge with dozers. Detailed cast blasts have not been designed at this stage and would need to be evaluated on a case by case basis to see if the savings in material movement costs would outweigh the increased blasting costs.

3.5 Blasting Costs

All blasting costs are budgetary and have been supplied by Orica for the basis of this project. All costs assume that drilling and blasting operations will be conducted by the mine. The mine is also responsible for providing power, fuel, water, developing access to infrastructure and the gates and fencing around the explosives manufacturing facility site. Costs are projected at a time of two years from now.

3.5.1 Capital Costs

The capital costs for the blasting infrastructure that the mine is responsible to provide are outlined below in Table 3.

Table 3 Explosives Infrastructure Capital Costs

BUILDING CAPITAL COSTS ($CDN)	
Buildings	$955,000
Concrete for Buildings	$720,000
Processing equipment	$6,200,000
Total Building Capital	**$7,875,000**

Other capital costs are needed for the equipment and are outlined below in Table 4

Table 4 Explosives Equipment Capital Costs

EQUIPMENT CAPITAL COSTS ($CDN)			
Type	Cost	Number	Total Cost
Repump MMU	$510,000	4	$2,040,000
Goat MMU	$265,000	1	$265,000
Pipeline MMU	$435,000	1	$410,000
Front-end loader	$244,000	1	$230,000
Pickup	$58,000	2	$116,000
Skid-steer	$55,000	1	$55,000
Magazine - 8' x 12' x 8'	$25,000	1	$25,000
Magazine - 6' x 8' x 8'	$15,000	1	$15,000
Total Equipment Cost			**$3,156,000**

Total capital costs explosives facilities and equipment is $11,031,000

3.5.2 Operating Costs

The cost of the explosives products required for a sample production hole is outlined in Table 5 below (the designed burden and spacing results in 3,002 tonnes of rock per hole):

Table 5 Explosives product cost

Electric Detonation Total Cost per hole		
Product Cost	$638.90	
Booster	$6.50	(1 per hole)
Electric Detonator	$15.55	
Detonating Cord	$11.05	(~17m/hole)
TOTAL	$672.00	$/hole
Product cost	$0.224	$/tonne material

Estimated monthly operating costs for operators, equipment, plant and power (of the explosives contractor) are outlined in Table 6 below. More detail on these numbers is given in Appendix C. The average monthly production of material (rock and ore) is calculated to be 13,000 kT.

Table 6 Monthly operating costs of explosives contractor

Monthly costs		
MMU/Plant operator - 3 req	$30,600	
Working Supervisor	$10,500	
Mechanic	$10,500	
MMU (blend truck) - 3 req	$22,500	
Pickup - 2 req	$3,000	
Development process vehicle	$5,000	
Forklift/Loader	$3,800	
Magazines - 2 req	$900	
Plant costs	$40,000	
LOM average plant operating costs	$10,273	
Estimated MMU operating costs	$3,000	
Power costs	$3,425	
Total monthly costs	$143,498	$/month
Monthly blasting costs	$0.011	$/tonne material

The mine is also responsible to provide the diesel for the explosives products. A summary of the estimated diesel costs is shown in Table 7 below.

Table 7 Fuel Costs for Explosives

Orica Estimated Fuel Consumption	44	L/tonne explosive

Sep 2012 PFS fuel cost	$0.937	$CDN/Litre
Explosives fuel cost	$41.00	$/tonne explosive
Powder factor	0.35	kg/tonne material
Explosives fuel cost	**$0.014**	**$/tonne material**

The total blasting costs (in $/tonne of material blasted) are shown in Table 8 below.

Table 8 Total blasting operating cost

Explosives cost	**$0.224**	**$/tonne**
Explosives fuel cost	**$0.014**	**$/tonne**
Monthly blasting costs	**$0.011**	**$/tonne**
TOTAL BLASTING COSTS	**$0.250**	**$/tonne**
with 10% contingency	**$0.275**	**$/tonne**

The contingency covers the increased costs that will result from specialty blasting along the final highwalls.

APPENDIX A

SABREX Study to Assess the Fragmentation Distribution Generated by Various Powder Factors

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22 Nov 2009

Executive Summary
Objective
Assessment Method
Findings and Discussion
Report
Introduction
SABREX Input
Results

Executive Summary

Objective

Assess the effect of powder factor on fragmentation and provide data for doing a pre-feasibility study on blasting at Seabridge KSM project using the SABREX blast model.

Assessment Method

The blast-engineering tool, SABREX, is used in this study. SABREX stands for **S**cientific **A**pproach to **B**reaking **R**ock with **Ex**plosives and it is a proprietary computer program of Orica. It is a modular computer code that incorporates technology with a number of tested programs that have been used worldwide. SABREX predicts the performance of blasts in terms of fragment size and distribution.

Findings and Discussion

The two rock types identified for blasting evaluations have a different fracture frequency and rock density. However, the strength value (Young's Modulus) of each rock type has less than 11% variation from the average of 41 GPa that is considered as medium hard for blasting. The SABREX modeling showed that when using same pattern size, the fragmentation produced for both rock types is almost the same.

Based on the results of the SABREX study, a powder factor of 0.96 kg/m^3 with 8.5m x 8.5 m pattern is indicated as a starting point for the blasting program. A baseline blast should

be conducted for each rock type as soon as possible to allow fine-tuning of the blasting program to meet the productivity requirements.

Report on the Powder Factor for the KMS Project Introduction

The Seabridge KSM (Kerr-Sulphurets-Mitchell) project is one of the five largest undeveloped gold projects in the world. Measured and indicated resources now total 34.5 million ounces of gold and 8.5 billion pounds of copper. The project lies 65 km northwest of Stewart, British Columbia.

There are four rock types classified for the main pit – Mitchell pit (Fig.1). But only two types of rock that are located in DOMAIN I and DOMAIN II have been recognized as a challenge for the blasting. The strength values (Young's Modulus) of these two types rock are 36.4 GPa and 45.2GPa. Rock with this kind of strength is considered as medium hard rock for blasting. The RMR values for these two rock types are 58 (II-325) and 76 (I -173) and the fracture frequencies are 7.69/m (II -325) and 1.41/m (I -173). So rock II -325 can be defined as fractured rock and rock I -173 can be defined as massive rock. The in-situ rock density is 2.65 gm/cc and 2.86 g/cc (Table 1).
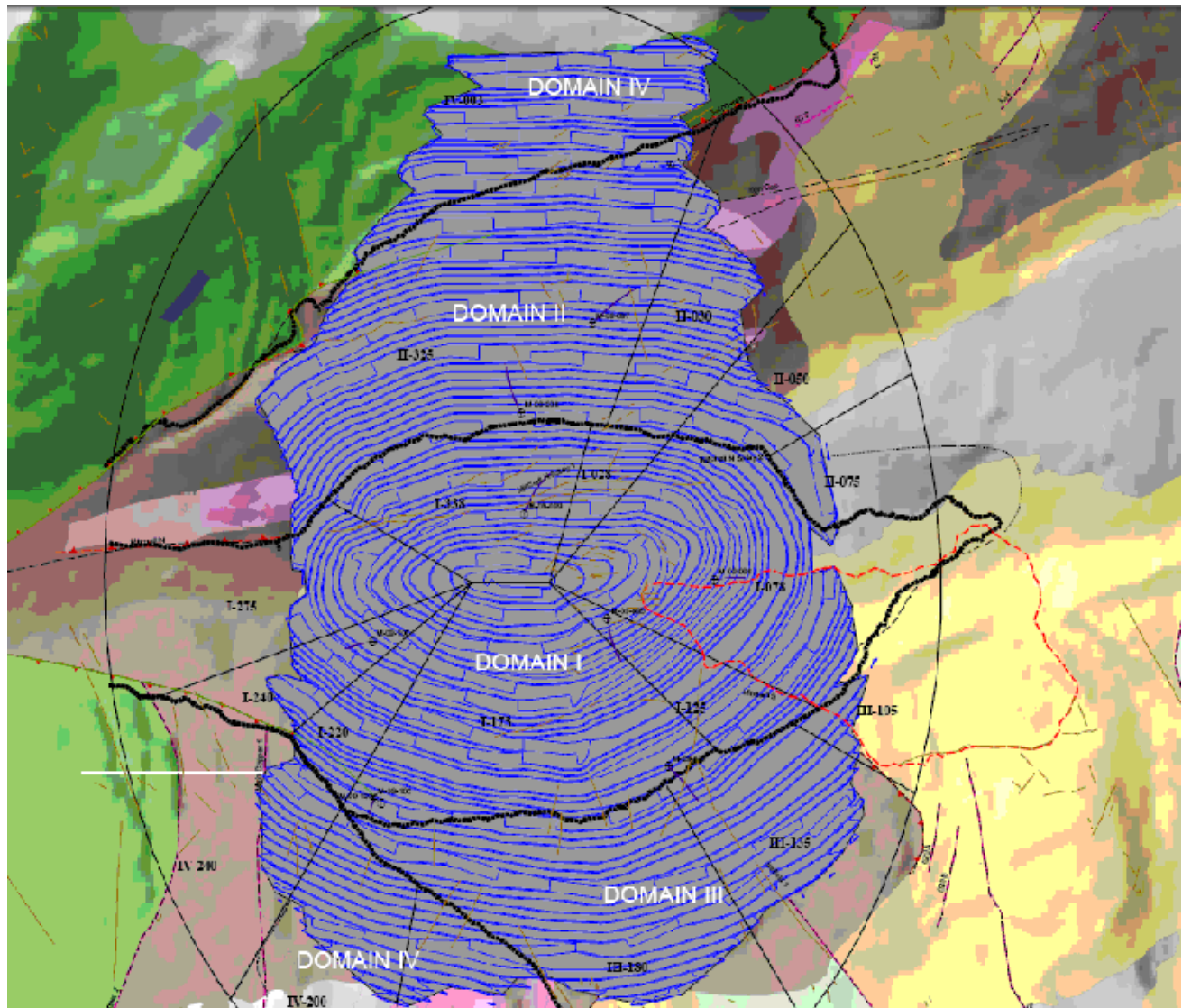
Figure 1. Mitchell Pit – The Main pit of KSM Project

Table1. Summary Geotechnical units and Design Properties

Input	Value	Units
Description	**I-173**	
Intact Rock		
Unit Weight	0.028	MN/m3
Young's Modulus	36.4	GPa
Poisson Ratio	0.25	
Uniaxial Compressive Strength	61	MPa
Brazilian Tensile Strength	3.9	MPa
Rock Mass		
RMR '76	75	
Joint Frequency	1.41	per m
Joint Orientation	56 - 350	dip - dip direction, in degrees

Input	Value	Units
Description	**II-325**	
Intact Rock		
Unit Weight	0.026	MN/m3
Young's Modulus	45.2	GPa
Poisson Ratio	0.2	
Uniaxial Compressive Strength	113	MPa
Brazilian Tensile Strength	9.3	MPa
Rock Mass		
RMR '76	58	
Joint Frequency	7.69	per m
Joint Orientation		degrees

SABREX Modeling and Input

SABREX uses data on the detailed geometry of the drilled and loaded pattern, detonation characteristics of the explosives and the dynamic properties of the rock to generate blast predictions. A total five pattern sizes were inputted to the modeling. Table 2 is showing the five cases of blast geometry input for modeling. The explosive used is Fortis Extra 70 (70% emulsion, 30% ANFO prill) loaded at a density of 1.25 g/cc.

Table 2 Blast Geometry Input for Modeling

	Base case	Case 1	Case 2	Case 3	Case 4
Bench					
Height (m)	15.0	15.0	15.0	15.0	15.0
Face angle	90.0	90.0	90.0	90.0	90.0
Sub-drill (m)	2.0	2.0	2.0	2.0	1.0
Pattern					
Type	Square	Square	Square	Square	Square
Drill dia. (mm)	311.0	311.0	311.0	311.0	311.0
Av. Burden (m)	8.0	8.5	9.0	7.5	8.0
Av. Spacing (m)	8.0	8.5	9.0	7.5	8.0
Powder Factor					
Collar (m)	6.0	6.0	6.0	6.0	6.0
Blast vol. (m^3)	9600	10838	12150	8438	9600
Av. PF (kg/m^3)	1.088	0.964	0.860	1.238	0.989

All patterns are drilled off with 311mm (12 $^{1/4}$") diameter holes on a 15m bench. It should be noted that none of these 5 cases presented an optimum design. These designs could however produce good fragmentation as a start. The drill pattern varies from 7.5m x 7.5m to 9.0m x 9.0m.

Both the Base Case and Case 4 have the same drill pattern but the latter has a meter less sub-drill resulting in a lower powder factor. This case examined the sensitivity of reducing sub-drill on fragmentation outcomes. Modeling results indicate a similar fragmentation outcome as the Base Case however an actual test blast program is recommended to evaluate the impact of reduced sub-drill on toe diggability.

Results

The SABREX results for rock I-173 are summarized in the following Table 3

Table 3 SABREX Fragmentation for I-173 Phyllic –Argillic altered rock

% passing (cm)	Base case	Case 1	Case 2	Case 3	Case 4
20% passing	5.4	6.0	6.6	4.7	5.4
30% passing	9.6	10.7	11.7	8.6	9.6
40% passing	14.6	16.0	17.5	13.1	14.6
50% passing	20.3	22.4	24.4	18.2	20.3
60% passing	27.4	30.3	33.3	24.6	27.4
70% passing	36.6	40.9	45.0	33.1	36.6
80% passing	50.2	56.1	62.1	45.4	50.2
90% passing	74.2	83.6	92.2	66.6	74.2
100%passing	190.0	200.0	210.0	180.0	190.0

Figure 2 is the fragmentation distribution curve with different powder factors for I-173 Phyllic –Argillic altered rock
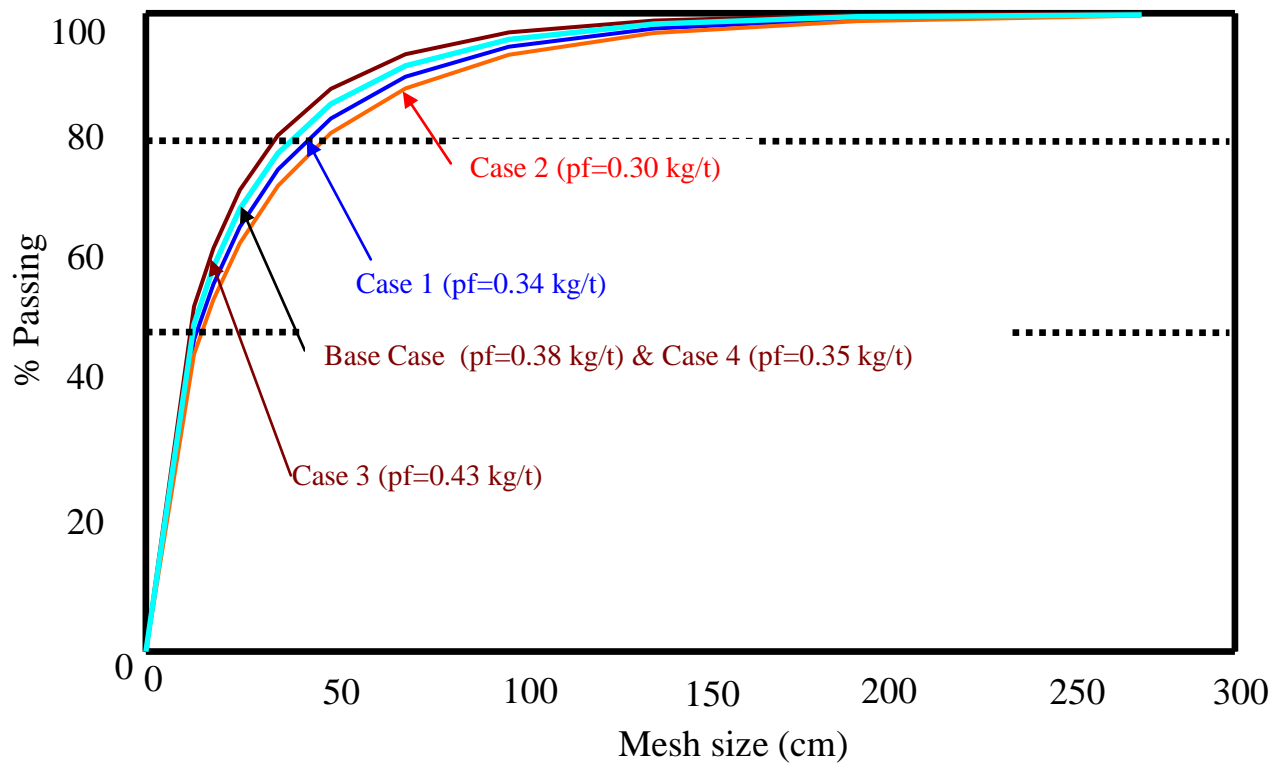

Figure 2 Computed fragmentation distribution for various powder factors (I -173 Phyllic – Argillic altered rock)

The SABREX results for rock II - 325 are summarized in the following Table 4

Table 4 SABREX Fragmentation for II -325 Intrusive rock and hornfelsed volcanics

% passing (cm)	Base case	Case 1	Case 2	Case 3	Case 4
20% passing	5.3	6.0	6.6	4.7	5.3
30% passing	9.5	10.6	11.6	8.5	9.5
40% passing	14.4	15.9	17.3	13.0	14.4
50% passing	20.1	22.2	24.2	18.1	20.1
60% passing	27.1	30.1	33.0	24.4	27.1
70% passing	36.3	40.5	44.6	32.8	36.3
80% passing	49.8	55.6	61.6	45.0	49.8
90% passing	73.4	82.9	91.5	66.1	73.4
100%passing	195.0	201.0	212.0	185.0	195.0

Figure 3 is the fragmentation distribution curve with different powder factors for II -325 intrusive rock and hornfelsed volcanics.
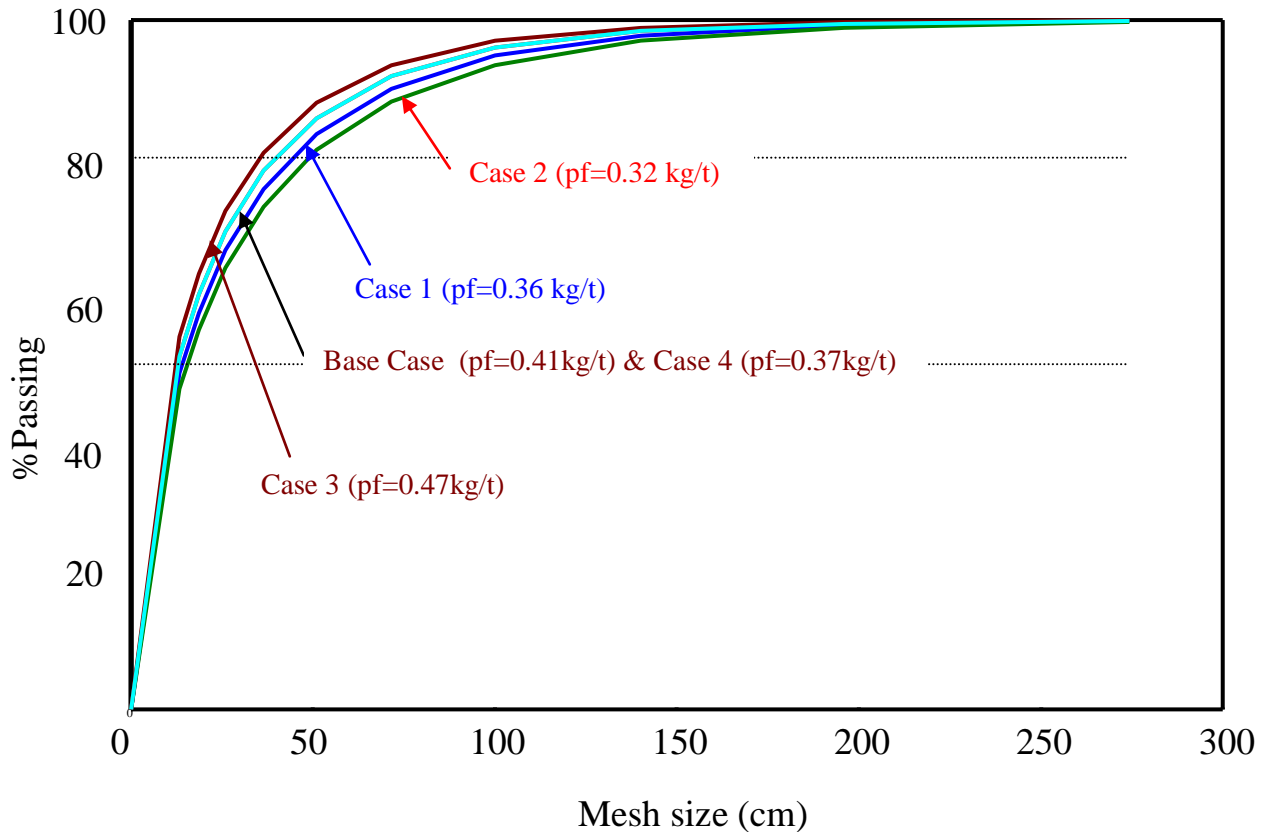

Figure 3 Computed fragmentation distributions for various powder factors (II – 325 intrusive rock and hornfelsed volcanics)

An analysis of the results in Table 3 and Table 4 indicates that the fragmentation generated from the two types of rock is very similar. Table 5 is the fragmentation passing size comparison for rock I-175 and II-325.

Table 5 Fragmentation % passing comparison between rock I -175 and II – 325

% passing (cm)	Base case	Case 1	Case 2	Case 3	Case 4
20% passing	5.4 (5.3)	6.0(6.0)	6.6(6.6)	4.7(4.7)	5.4(5.3)
30% passing	9.6(9.5)	10.7(10.6)	11.7(11.6)	8.6(8.5)	9.6(9.5)
40% passing	14.6(14.4)	16.0(15.9)	17.5(17.3)	13.1(13.0)	14.6(14.4)
50% passing	20.3(20.1)	22.4(22.2)	24.4(24.2)	18.2(18.1)	20.3(20.1)
60% passing	27.4(27.1)	30.3(30.1)	33.3(33.0)	24.6(24.4)	27.4(27.1)
70% passing	36.6(36.3)	40.9(40.5)	45.0(44.6)	33.1(32.8)	36.6(36.3)
80% passing	50.2(49.8)	56.1(55.6)	62.1(61.6)	45.4(45.1)	50.2(49.8)
90% passing	74.2(73.3)	83.6(82.9)	92.2(91.5)	66.6(66.1)	74.2(73.4)
100%passing	190.0(195)	200.0(201)	210.0(212)	180.0(185)	190.0(195)
Rock	I-173(II-325)	I-173(II-325)	I-173(II-325)	I-173(II-325)	I-173(II-325)

This means if identical blast design parameters are used for both rock I - 175 and rock II - 325, fragmentation results from SABREX modeling for both rocks are very close. This appears logical after examination of the geotechnical properties for rock I-175 and II-325. Rock II -325 has higher rock strength (Young's Modulus 45 GPa) but the rock is more fractured (Joint frequency 7.69/m). Rock I -175 has less rock strength (Young's Modulus 36 GPa) but the rock is less fractured (Joint frequency 7.69/m). From a blasting perspective, these two rocks can be categorized as one type of rock – medium hard rock.

Fragmentation is considered to be one of the most influential factors to productivity. Depending on the capability of the truck and shovel team, one may find a distribution from Figure 2 or Figure 3 most effective to handle.

On the basis of these results, it appears that a powder factor of 0.96 kg/m^3 with 8.5m x 8.5m pattern is reasonable to use to design start-up test blast program. The results of this start-up program should be closely monitored to establish a baseline for further optimization.
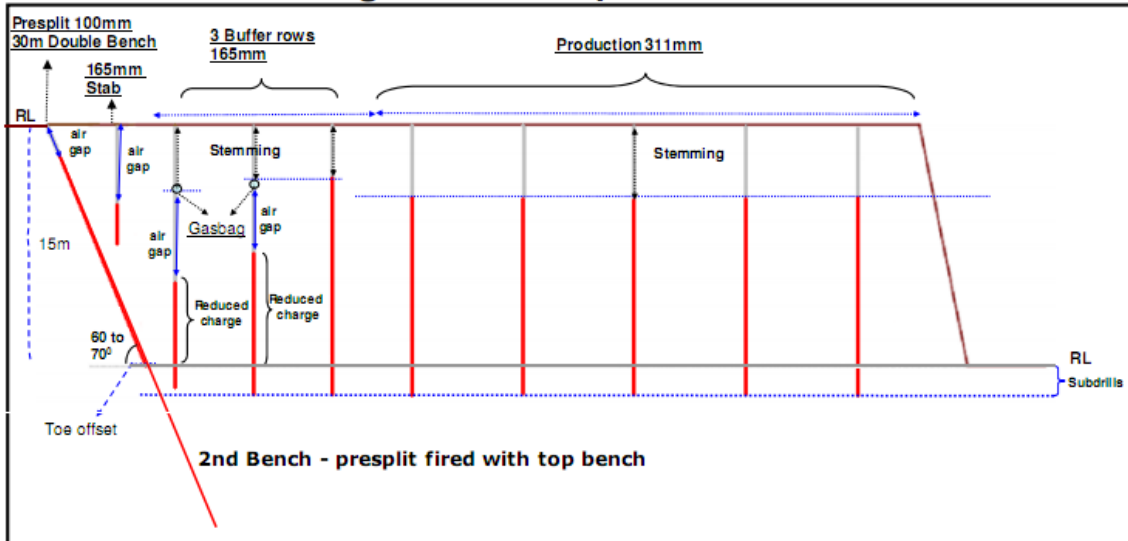
APPENDIX B

Design Assumptions (DRAFT)
9/25/2009

CASE	DESCRIPTION	ASSUMPTIONS
A	SINGLE BENCH, CONVENTIONAL MINING	- 15 m BENCHES, 65° BENCH FACE ANGLE[1] - 2 m BREAK-BACK ON BERMS NOT AFFECTED BY FOLIATION, 1 m ON THOSE PARALLEL TO FOLIATION STRIKE BECAUSE MOST OF THE ANTICIPATED BREAK-BACK WILL OCCUR DURING MUCKING - BENCH SCALE JOINTS WILL BE REDUCED TO RESIDUAL STRENGTH BY PRODUCTION BLAST DISTURBANCE.
B	SINGLE BENCH, CONTROLLED BLASTING	- 15 m BENCHES, 70° BENCH FACE ANGLE[1] - 0 m BREAK-BACK ANTICIPATED ON BERMS - BENCH SCALE JOINTS WILL REMAIN AT NEAR PEAK SHEAR STRENGTH DUE TO REDUCED DISTURBANCE FROM CONTROLLED BLASTING.
C	DOUBLE BENCH, CONVENTIONAL MINING	- 30 m BENCES, 65° BENCH FACE ANGLE[1] - 2 m BREAK-BACK ON BERMS NOT AFFECTED BY FOLIATION, 1 m ON THOSE PARALLEL TO FOLIATION STRIKE BECAUSE MOST OF THE ANTICIPATED BREAK-BACK WILL OCCUR DURING MUCKING - BENCH SCALE JOINTS WILL BE REDUCED TO RESIDUAL STRENGTH BY THE PRODUCTION BLAST DISTURBANCE.
D	DOUBLE BENCH, CONTROLLED BLASTING	- 30 m BENCHES, 70° BENCH FACE ANGLE[1] - 0 m BREAK-BACK ANTICIPATED ON BERMS - BENCH SCALE JOINTS WILL REMAIN NEAR PEAK SHEAR STRENGTH DUE TO REDUCED DISTURBANCE FROM CONTROLLED BLASTING.

For all cases:
1. Bench face angles will be controlled by foliation when strike parallel (60 degrees).
2. Fully depressurized bench scale.
3. Geological structures fully depressurized at interramp slope scale.

Generalized Configuration - Top Bench of Double

Type	Hole Dia.	# of rows	Length (m)	Burden (m)	Spacing (m)	Explosive	Initiation Method	kg / hole	PF
Presplit	165mm	1	32m	-	1.8	50mm packaged	Electronic	32	0.55 Kg/m2
Stab	165mm	1	~8m	3.0	5.5	Bulk emulsion/AN	Electronic	50	0.35 Kg/BCM
Buffer	165mm	3	1 bench	4.8	5.5	Bulk emulsion/AN	Electronic	200	0.5 Kg/BCM
Prod	311mm	as required	1 bench	8	9.2	Bulk emulsion/AN	Electronic	807	0.75 Kg/BCM

Notes
1: • This diagram is not intended to show actual firing configuration • for budgeting purposes only
2: • Presplit for the 2nd bench is fired with the top bench • if fired as a single, bench presplit will have to be drilled and fired separately
3: • Stab hole burden, loading and depth changes depending on face angle • budget number given accurate average for all configurations
4: • Loads/powderfactors are typical • will vary with domains/zones • mean figures displayed
5: • Presplit (32mm cartridge product) is fired double bench • 32m drill hole needed for 70 degree face • 35m drill hole needed for 60 degree face
6: • Bulk explosive will depend on wet or dry conditions • kilograms remain constant

APPENDIX C

Seabridge Gold Project:

The objective of the operation is to produce a 70/30 emulsion/ANFO blend for the Seabridge Gold Project. Nominal plant capacity is 80te/day with a peak production rate of 150te/day. Budgetary costs provided at this time assume drilling and blasting will be conducted by the mine. Blasting services are excluded from the normal operation, but will be offered by Orica under separate terms.

Delivery of the explosives to the borehole is part of the Orica SLA and will be accomplished using MMUs.

Operational Details:

Borehole delivery:
Time to fill MMU with gasser – 5min
Time to fill MMU with emulsion– 25min
Time to empty MMU – 60 min
Drive time to pit – 60min return
Capacity of MMU = 14te

Example:
MMU 1 – starts 7:00am leaves site at 8:00am after inspections and filling.
Returns for filling at 10:00am – leaves at 10:30
Returns for filling at 12:30pm – leaves at 1:30pm
Returns for filling at 3:30pm – leaves at 4:00pm
Returns at 6:00pm – is cleaned, greased, fuelled, etc.

Manning:

The plant will operate 12 hours per day, 7 days per week, 365 days per year. This will be accomplished by rotating shifts. As the mine is remote, the normal shift will be 2 weeks in and 2 weeks out.

Recommended Operations:

1-   Years 1-2

Staffing: (per rotation)
        2 – MMU operator
        1 – Working Supervisor
        1 – Mine mechanic/electrician – part time requirement 15 hrs/wk

Rolling Stock:
        2 – MMU repump type
        1 – MMU repump type (spare)
        2 – Pickup truck
        1 – Front end loader w/ fork attachment
        1 – MMU (Goat type) for development work

Other Equipment:
        1 – Type 4 magazine – 6' x 8' x 8'
        1 – Type 4 magazine – 8' x 12' x 8'

Years 3+

Staffing (per rotation)
 3 – MMU operator
 1 – Plant operator
 1 – Working Supervisor
 1 – Mine mechanic/electrician – part time requirement 30 hrs/wk

Rolling Stock:
 3 – MMU repump type
 1 – MMU repump type (spare)
 2 – Pickup truck
 1 – Front end loader w/ fork attachment
 1 – MMU (Goat type) for ongoing development work

Other Equipment:
 1 – Type 4 magazine – 6' x 8' x 8'
 1 – Type 4 magazine – 8' x 12' x 8'

The following information is to assist with the preparation of a feasibility study for the Seabridge Gold Project and does not constitute Orica's final bid. Orica believes that these numbers are fair and accurate; however, these numbers are not binding.

There is intellectual property in some of the processing equipment and Orica reserves the right to repurchase this equipment from Seabridge Gold.

	$CAD
Personnel Costs: (each)	
MMU / Plant Operator	$10,200 per month
Working Supervisor	$10,500per month
Mechanic	$10,500 per month
Equipment Costs: (each)	
MMU (blend truck)	$7,500 per month
Pickup	$ 1,500 per month
Development process vehicle	$5,000 per month
Forklift/loader	$3,800 per month
Magazines	$450 per month
Plant costs (amortized over 10 years-monthly rate)	approx. $40,000 per month
Fees after amortization period for plant (maintenance fees)	To be determined from average maintenance costs at/near end of amortization period
Explosives Costs (budgetary only)	
Fortan Extra 35 (dry hole product)	$58.00 per 100 kilograms
Fortis Extra 70 (wet hole product)	$65.00 per 100 kilograms
Senatel Powersplit 50 mm x 10 m (wall control product for single benching)	$210.50 per case
Senatel Powersplit 50 mm x 40m (wall control product for double benching)	$239.50 per case
Blasting Accessories costs (budgetary only)	
Pentex boosters-1 lb	$6.50 each
Ikon RX 20meter detonator (electronic)	$42.00 each
Harness wire (6 rolls x 400 m/case)	$375.00 per case
Cordtex AP-detonating cord	$65.00 per 100 meters
Exel MS 18 meter detonator (non electric in hole detonator)	$940.00 per 100 units
Exel MS Connectors (surface delays)	$615.00 per 100 units

Estimated Operating Costs:	
Estimated Plant Operating costs for years 1-3	$8,000.00/month
Estimated Plant Operating costs for years 4+	$10,500.00/month
Estimated MMU Operating costs – excluding fuel	$3,000.00/month
1- Hydro, Fuel and Water to be supplied by mine	
Estimated Fuel Consumption	44.0 litre/te of product
Estimated Water Consumption	123.0 litre/te of product – minimum 400 l/day
Estimated Power Consumption	32,000 kwh/month summer 75,000 kwh/month winter

CAPITAL COSTS $CAD	
Rolling Stock: (each)	
Repump MMU	$510,000
Goat MMU	$265,000
Pipeline MMU	$435,000
Front End loader with Forks	$244,000
Pickup	$58,000
Skid Steer loader with forks	$55,000
Magazine Type 4 – 8' x 12' x 8'	$25,000
Magazine Type 4 – 6' x 8' x 8'	$15,000
Equipment:	
Buildings (excludes AN Prill storage building)	$955,000
Concrete for Buildings (320 m3 @2000 per m3)	$720,000
Processing equipment includes piping, electrical and installation	$6200,000

Mine to provide:

- Hydro 600V, 400A service to the site.
- Water – clean process water & potable via well or delivery truck
- Diesel delivered as required to the site
- Mechanic – if the option is chosen
- Electrician – if that option is chosen
- Use of maintenance garage for decontaminated process vehicles – to replace engines, transmissions, etc
- Place to put "used" oil, hydraulic fluids, etc
- During construction the use of a crane will be required – estimate 6 weeks to set silos, buildings, elevators, screw conveyors, tanks, etc
- Mine to provide site preparation for installation of buildings and truck traffic
- Mine to erect gate and necessary fencing around site meet Explosives Regulatory Requirements – 6 feet high 3 wire
- Mine will be responsible for magazine site preparation
- Environmental Assessment including the explosives plant and magazines
- Storage for 400te of Ammonium Nitrate Prill in 1te totes. This is to serve as an emergency reserve. When combined with the AN in the silos and the AN in solution, this will provide 10 days of service. This will need to be located a minimum of 120m from the explosives plant. Transportation from storage to the plant is the responsibility of the mine. Stock will need to be "turned" every 6 months.
- All permits other than those specified as Orica to provide
- Accommodations for employees regularly on site and occasional visitors. Visitors would typically number no more than 2 at any one time. Typical visitors are safety and operations personnel and management, technical personnel – chemists, engineers, blasting consultants

Orica to provide:

- Design, procurement, delivery and installation of all buildings and processing equipment including piping and electrical, except the AN storage building listed above.
- Procurement and delivery of the requested quantity of delivery vehicles and licensing as required by the Explosives Regulatory Division of NRCAN
- Procurement and delivery of requested explosives magazines meeting the requirements of the Explosives Regulatory Division of NRCAN
- Factory license as required by the Explosives Regulatory Division of NRCAN

Special Considerations for Environmental Assessment:

- Boiler emissions for a 60hp – diesel fired boiler
- AN dust emissions – Note: the yearly consumption of AN will be transferred 2x (i.e. fill a silo and then fill a tank or truck)
- Diesel fuel emissions from storage tank and transfer to process
- Evaporation system will boil off water
- Surfactant tank emissions

On Site Storage:
- 60 te of surfactant
- 140te of Ammonium Nitrate Prill
- 80te of emulsion
- 300te of Ammonium Nitrate Solution
- 10te of water
- 23000 litres of diesel
- 5000 litre fuel phase tank
- 600 litres of aqueous Sodium Nitrite
- 600 litres of aqueous Ethylene Glycol
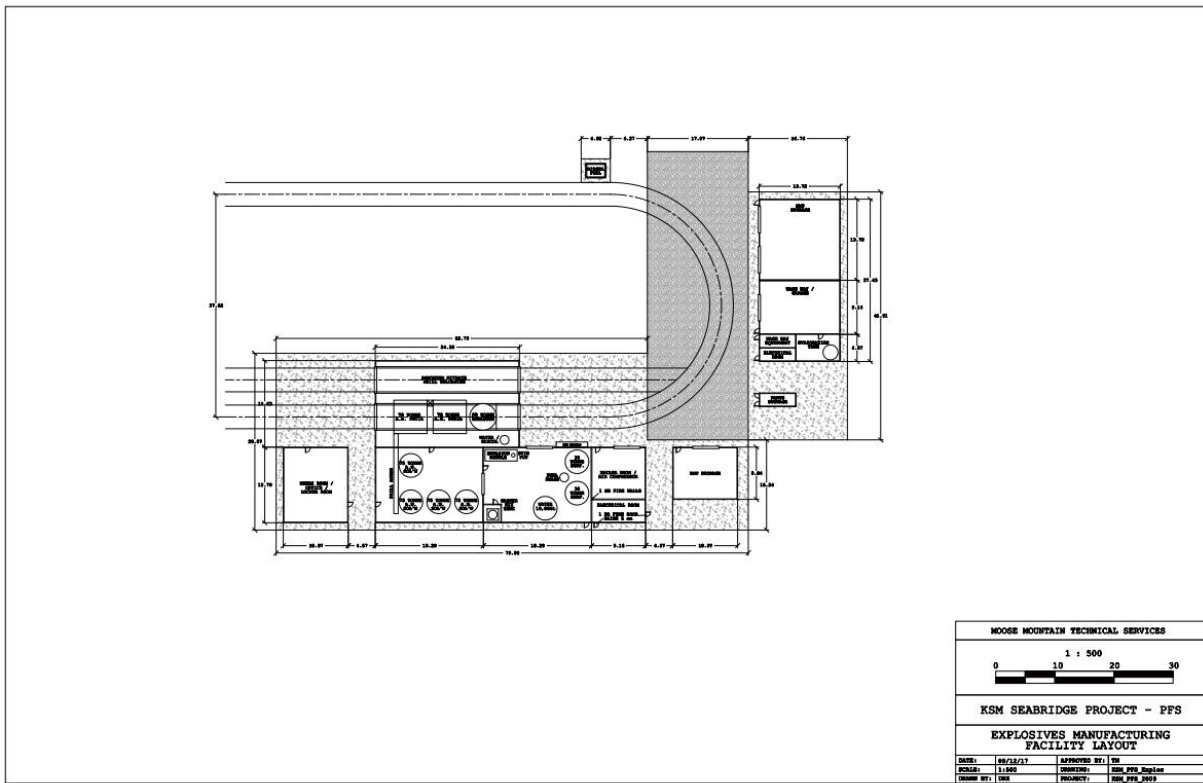
KSM - Mitchell Pit

Pre-Feasibility Study Wall Control Blasting

For Pre-Feasibility Study budgeting purposes <u>only</u>

Orica Canada Inc.

21-10-2009

Overview

Orica Canada was contacted by Moose Mountain Technical Services (MMTS) to give advice and rational input into suitable wall control blasting practices that will be required for the Pre Feasibility Study (PFS) of the Mitchell pit in the proposed KSM project. The contained information herein is related directly to that request, and is only intended for budgeting use during this specific Pre-Feasibility Study.

It is the purpose of this paper to give an initial indication of the practices that would be required for wall control blasting in this proposed Mitchell pit, so that necessary costs related to blasting activities can then be generated for use in the Pre-Feasibility Study.

All information has been supplied in good faith, and Orica Canada Inc cannot be held accountable for differences seen in the field during implementation, in actual numbers or blast performance during operations, to the budgeted numbers that are put forwards here for use in the PFS.

The information herein is generally known to be best wall control practices for a given final pit shell design such as the one proposed.

This information is for costing purposes in the pre-feasibility stage only, and should not be considered fit for transfer into implementation by operations. Further and ongoing consultation will be required from Orica blasting professionals as information comes available and at critical stages of the project's development.

The KSM project – Mitchell Pit

Key Quotes from "Appendix D9 - BGC - 20090430 Design Criteria - DRAFT.pdf"

4.1.1. Blasting
The PEA level design criteria are based on the assumption that generally good blasting practices will be used, especially for the final pit walls. These controlled blasting techniques may include trim and buffer blasting or pre-split blasting. Specific drill setups may be required for these modified production blasts, resulting in an increased cost.

4.1.3. Slope Monitoring
"The proposed Mitchell pit represents the upper range of achieved open pit slope heights in the world."

The KSM project's Mitchell pit will undoubtedly be one of the world's most productive and high value gold/copper mines, containing the world's tallest engineered rock face of 1650m. Orica certainly recognises the importance of this, and the value that is involved in creating the planned geometries outlined in the mine design. It is the successful completion in full of the intended pit design which is the true key to unlocking the potential economic value of the Mitchell pit.
Due to the unprecedented nature of this proposed task, Orica recommends that only the best possible blasting practices should be used. This aligns with the customer's assertion that "controlled" blasting will be required.

It is highly recommended that for the final pit shell blasting that proposed options A and C should not be considered as viable practises, and as such they have not been investigated in this report. However during the creation of interim pit shells, there may be opportunities for less stringent blasting practices (possibly options of A and C), variations to the best practice concepts given here, that may be possible to implement. Such second-rate concepts will produce outcomes of lower quality, and will not be discussed here.

The intended blasting outcomes that will be investigated are:

D	DOUBLE BENCH, CONTROLLED BLASTING	- 30 m BENCHES, 70° BENCH FACE ANGLE - 0 m BREAK-BACK ANTICIPATED ON BERMS - BENCH SCALE JOINTS WILL REMAIN NEAR PEAK SHEAR STRENGTH DUE TO REDUCED DISTURBANCE FROM CONTROLLED BLASTING.

The methodologies delivered in this paper are what we know to be best practice, put forwards with the intent of fulfilling these required blasting outcomes.

Proposed wall control methodology for use in the PFS

After reviewing the given data, and due to the fact that the project is only in the pre feasibility stage, the best approach to budget for wall control blasting techniques is to adopt a singular "best practice", and use this everywhere in the pit.
The blanket approach suggested is the best practical wall control practice available, and generally gives more preferable results – however it must be noted that it is also the most expensive way of blasting per BCM and m2. The basic concepts of this methodology are the same for both the upper and lower benches of the double stack:

Drilling
- 165mm hole drilled from the from the crest to the toe of the desired face angle (70 or 60 deg) – both benches 30m (2x15m) drilled at the same time in one pass
- 165mm stab hole
- 3 rows of 165mm buffer holes
- 251mm production holes after this

Loading
- Initiate all holes with electronic detonators
- Load 165mm holes with 50mm presplit product (this is called presplitting – these are called presplit holes)
- Load 165mm stab holes with bulk explosive, no stemming
- Load 165mm buffer holes with varying charge weights of bulk explosive, leave air gap between explosive and stemming
- Load 311mm production holes with bulk explosive

Firing
- Face angle holes fired as double bench presplits
- All shots need to be totally free faced
- Each shot uniquely timed with electronic detonators dependant upon the various contributing factors that relate to blast outcome (geology, burden in front, fire direction, hole locations and blast geometry, etc)
- Each shot modelled for vibration effects using signature waveforms and a Monte-Carlo waveform analysis process

A better look of the recommended blasting geometries for budgeting use in the pre feasibility study can be seen in the attached spreadsheet "KSM - Mitchell Pit - Wall Control PFS.xls". For the pre

feasibility study to be conducted by MMTS, only the drilling and loading information needs to be considered for budgeting purposes at this stage - the organising of actual blast shapes and sizes and their firing order is an operational concern.

Further, more detailed studies based on domain and zone/rocktype information are possible at the *feasibility study* stage. It could is expected that the wall control blasting concepts and resultant budget numbers as given here will change somewhat based on the recommendations of more applicable blasting techniques in these different zones.

Notes of consideration with regards to the PFS budgeting process

Double Bench face angle drilling issues
Due to the said Bench face angle of 70 degrees, if the pre-splitting (presplitting is using packaged presplit products – although this concept is valid for any type of double bench wall control done) is not done in one single 30m pass (2 x 15m - double bench presplitting), there will be a need to stand off the toe of the top bench to get the drill in to drill the second bench of the double bench split, most probably in the order of the magnitude of 2m of standoff. This stepout would decrease the effective double bench face angle from 70 to 66.7 degrees. This concept is illustrated in the "Single or double pass drilling" tab in the accompanying "KSM - Mitchell Pit - Wall Control PFS.xls" spreadsheet. To keep the overall interbench angle the same, this loss of 2m will have to be absorbed in the berms, therefore reducing each berm width by 2m.
Another option would be to drill the second bench of the split at a steeper angle (near vertical). This will most probably not be allowed geotechnically, as the steeper angles would decrease the stability of the pit walls.
Also, if the double bench is split in two passes, risks of rockfall incidents will rise having drills/drillers/blasters working right up against a highwall with only 2m of effective berm width, something which will certainly reduce levels of worker safety.
This drilling constraint with regards to face angle drilling/presplit is important, as it will massively impact operational scheduling and safety. For this issue to be properly resolved, the drill selection process needs to have this complication included in its considerations.

Explosive Selection

Bulk Products
A good starting point for finding the right bulk explosives that will be best suited for application in this pit would be to assume a 70%/30% emulsion/prill mix for wet holes and a 35%/65% emulsion/prill mix for dry holes.
It should be assumed that at least half of the pit will be "wet", and will need the 70% emulsion based product.
These numbers are for budget purposes only, and may change depending on mining conditions and needs.

Wall Control Products
To match the 165mm holes recommended, a 50mm detonator sensitive packaged product internally traced with detonating cord – a pre-split product – will be required.

Drill Selection

To complete the drill designs as mentioned in this brief, the correct drills would be required to do the job. A brief description of each type of drill and their needed capabilities is given below.

Face Angle drilling

~6 1/2" Down Hole hammer drill. 36m drilling depth minimum capability needed to do 60 degree face angles. Used for presplit drilling. If equipment selection is optimised, the drill may also be used for buffers, and horizontal dewatering/slope/ground support/depressurisation holes.

Buffers

~6 1/2" Down Hole Hammer – combination of deck drill and front mount fleet. 32m drilling depth minimum capability for double benching. Need to be able to drill angles to be able to do pre shears on temp walls or to combat potentially undesirable faces.
If equipment selection is optimised, front mount drills can also be used for horizontal dewatering/slope/ground support/depressurisation holes.

Production rigs

Rotary rigs need that need to have drilling capability for holes up to 311mm. Holes greater than 311mm may cause excessive levels of vibration due to charge weights, and increased spacing will decrease parity of blasthole ore control sampling. Production fleet needs to have combination of diesel (for mobility/flexibility) and electric (for efficiency) powered rigs.
Some rigs need carousel to have 32m drilling depth minimum capability for double benching. Need to be able to drill angles to combat potentially undesirable faces.