



Crushing and Screening Relocation at Steensby

Trade-off Study

Rev. 0

July 19, 2011

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1. Executive Summary

The Mary River Project process consists of crushing and screening to produce high quality directshipping iron ore in form of lump and fines.

This trade off study (TOS) provides information on the crushing and screening options for Baffinland's Mary River Iron Ore Project. It outlines the advantages and disadvantages of four options. These include: lump / fines screening at both Mary River and Steensby – double deck screening at mine site (Option 1); lump / fines screening at both Mary River and Steensby – single deck screening at mine site (Option 2); eliminating lump / fines screening at Mary River and only having lump / fines screening at Steensby (Option 3), and only having secondary crushing at Mary River, and considering tertiary crushing and lump / fines screening at Steensby (Option 4). The two options 1 and 2, previously examined by Aker Kvaerner, involved either having lump and fines screened out at the Mary River and Steensby, or producing a bulk product at the Mary River and having lump and fines screened out at Steensby. These options were outlined in Aker Kvaerner – Baffinland Screening Options (Definitive Feasibility Study – Appendix H4). The third option involving the transport of primary crushed ore directly to Steensby by rail and carrying out all screening and stockpiling at the port location was reviewed by AMEC in the Technical Decision Memorandum TDM-159952-2100-134-009. Both Aker Kvaerner and AMEC design are based on the concepts of Option 1.

Option 2 and 3 have been ruled out of further design work in previous study by AMEC because during alternating thaw-freeze cycles, fines produced would agglomerate contaminating the lump product in Option 2, and risk to rail system and subsequent higher capital and operating costs in Option 3.

Option 4, involving primary crushing and open circuit secondary crushing at Mary River, and transporting a bulk mixture of coarser lump and fines to Steensby for screening and tertiary crushing is discussed in more details in this TOS.

As lump iron ore has a higher value compared with fines, the most important concern in Option 4 is the agglomeration of fines to lump which may affect the quality of final lump product. Predicting the behaviour of frozen agglomerated fines within lump is complicated and requires testing, however to have an overall understanding of the ratio of agglomerated fines to lump, Hatch made an estimation for this ratio in Option 4. Depending to what portion of agglomerated fines may separate from lump during screening and tertiary crushing, four different probabilities were considered. With a minimum of 65% final lump product, with natural moisture content of the ore, in the worst case there would be about 22% fines agglomerated to the lump.

Mitigation plans to avoid fines sticking to the lumps are also presented. These plans can be put in place at a later date, well after the mine is started. They will enable the operators to minimize fines content in lump product. However it is recommended to perform the testwork of fines sticking.

In order to meet the buyers' contract specifications for Mary River lump iron ore product, the maximum agglomerated fines in the final lump product should be maintained well below 4%.







Thus, the results from testwork planned to be conducted on Mary River samples should confirm the separation of at least 75% of agglomerated fines from lump during screening and tertiary crushing to make the Option 4 process wise feasible.

Hatch does not recommend compromising the quality of the Mary River lump product. Therefore Hatch's recommendation for Mary River Project is optimised Option 1. Hatch also recommends to develop Option 4 simultaneously with the development of optimised Option 1.







2. Objective

This trade off study (TOS) provides information about advantages and disadvantages of various crushing and screening relocation options and compares their operational and capital costs in order to make the best decision for the project crushing and screening arrangement.







3. Mary River Process Options

The current scope of crushing and screening for the Mary River Project is based on Option 1 (Aker Kvaerner DFS). A summary of general features of the four options which are explained in following is shown in Table 1.

Table 1: Mary River Project Crushing and Screening Options

	Option 1	Option 2	Option 3	Option 4
Primary Crushing at Mary River	✓	✓	✓	✓
Primary Screening at Mary River	✓	✓		
Secondary Crushing at Mary River	√ ‡	√ ‡		√ †
Separate L/F Products at Mary River	✓			
Mixed L/F Product at Mary River		✓	✓	✓
Primary Screening at Steensby			✓	✓
Secondary Crushing at Steensby			√ ‡	
Tertiary Crushing at Steensby				√ ‡
Secondary Screening at Steensby	✓	✓	✓	
Products at the Mary River	Two separate lump (6.3- 31.5 mm) and fines (-6.3 mm) products	A single mixed (-31.5 mm) lump/fines product	A single coarse (-180 mm) [¶] lump/fines product	A single bulk (-43 mm) ¹ lump/fines product

[†]open circuit crushing

3.1 Option1 – Lump and fines screened at the Mine Site and Steensby

After primary crushing, the ore would be primary screened to produce three products: an oversize (+32 mm), a lump (-32 mm +6 mm), and fines (-6 mm). The oversize would be further crushed in a secondary crushing plant and re-circulated back to the primary screen feed, while the lump and fines produced would be stockpiled separately. Each stockpile would further be broken out into off-spec and on-spec products. The design of material handling takes into consideration the blending requirements to make a final on-spec product, which would be reclaimed for subsequent rail loading to the Steensby port facility. At Steensby the lump product is further screened in a secondary screening plant to remove any associated fines that primary screening did not remove, or that were produced from ore breakdown of repeated handling of lumps. A simplified block flow diagram for Option 1 is shown in Figure 1.



[‡]closed circuit crushing

I product sizes are based on %80 passing the screen





3.1.1 Advantages

- · Great flexibility in product blending
- More available space for stockpiling
- Better quality lump with a lower risk of frozen or agglomerated fines with lump
- Decouples the mine site from the rail therefore not allowing down times from upstream equipment to affect the rail schedule.

3.1.2 Disadvantages

- Aker Kvaerner's report states \$11.3 million increase in cost over that of Option 2
- Lumps must be re-screened to remove fines generated during material handling.







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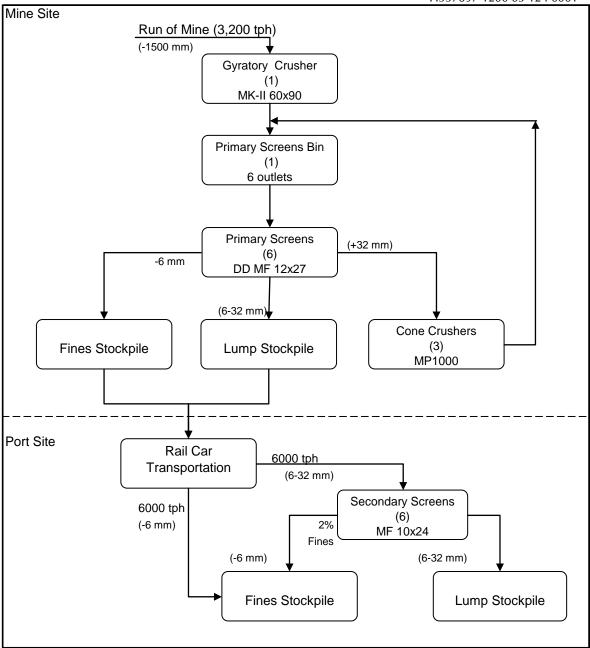


Figure 1: Simplified block flow diagram for Option 1





3.2 Option 2 – Bulk screening at the Mine Site and rail to Steensby where lump and fines are screened out

Similar to Option 1, the mine ore is primary crushed and then primary screened. Only two products are produced from primary screening: an oversize (+32 mm) and a bulk undersize (-32 mm). The oversize would be secondary crushed and recycles back to screen feed while the bulk undersize would go to either an on-spec or an off-spec stockpile. The design again takes into consideration the blending requirements to produce an on-spec bulk product. The on-spec product is then reclaimed and transported by rail to Steensby where it is then secondary screened to produce a lump and a fines product. Each product is stockpiled until reclaimed for ship transport. Figure 2 shows a simplified block flow diagram for Option 2.

3.2.1 Advantages

- Some flexibility in product blending (Chevron blending at port)
- Aker Kvaerner's report states \$11.3 million decrease in cost over that of Option 1.

3.2.2 Disadvantages

- During cold weather operation, fines produced would agglomerate contaminating the lump product
- Lose of flexibility for product storage at Steensby. Fines would occupy valuable space required to store lump
- Would require additional stockpile storage space for off-spec material.







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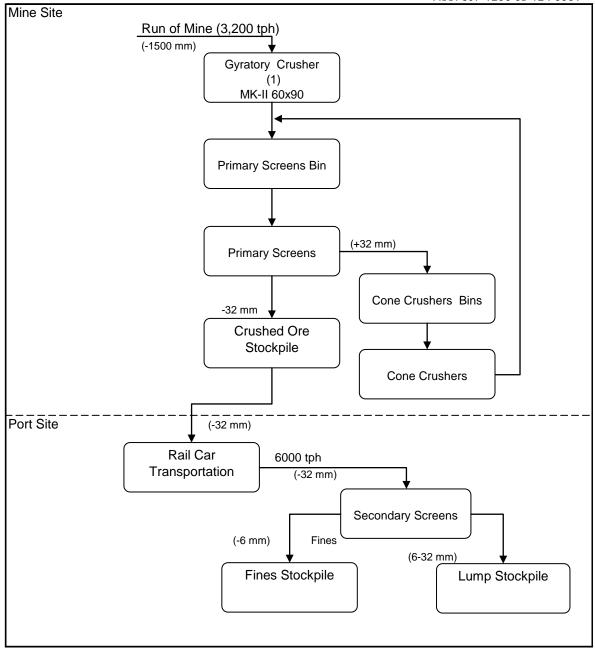


Figure 2: Simplified block flow diagram for Option 2





3.3 Option 3 – Primary crushing at the Mine Site and rail to Steensby where lump and fines are screened out

Option 3 involves only primary crushing at the mine site and then loading the primary crushed product (-250 mm) to rail directly to be shipped to Steensby. Once at Steensby, the ore is then screened and secondary crushed to produce two products, lump and fines. The products would be stockpiled to the stockpiling and blending scheme mentioned in Option 1 and Option 2. A simplified block flow diagram of Option 3 is illustrated in Figure 3.

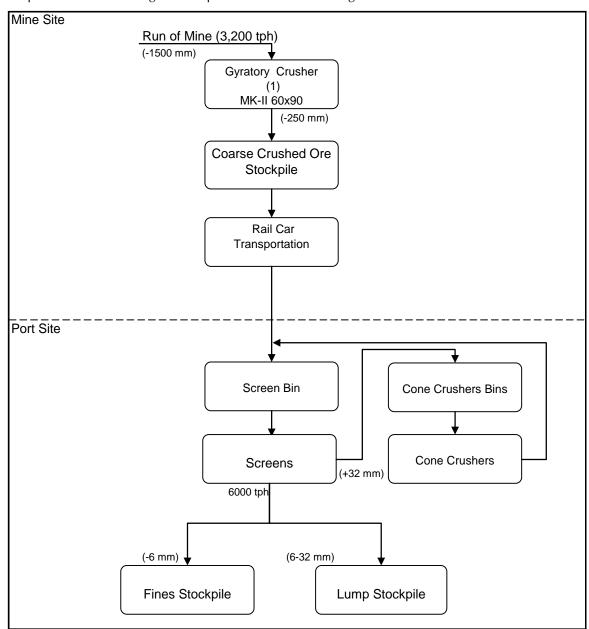


Figure 3: Simplified block flow diagram for Option 3





3.3.1 Advantages

- Locating most equipment at Steensby would be better in terms of operations in one area for maintainability and accommodating workforce
- No need to re-screen lumps to remove fines generated through material handling
- Decouples the mine site from the rail therefore not allowing down times from upstream equipment to affect the rail schedule.

3.3.2 Disadvantages

- Risk to rail system rail cars would all need to be designed with heavier construction and reinforcement to handle the impact of the larger particle size of approximately 200 mm to 300 mm size. This would significantly increase the cost of the rail cars and reduce the carrying capacity of the overall train set.
- The larger rock would reduce the carrying capacity to some extent due to increased bulk void (this lowers bulk density) further reducing the carrying capacity which potentially drive the rail to go to a three train set rather than a two train set (increasing capital and operating costs)
- Canarail expressed great concern that a significant schedule delay would occur for the rail system design if the option 3 was accepted
- During the loading / unloading process there is usually some spillage expected. Spillage of larger rock would increase the risk of damage to break lines causing safety and higher maintenance cost and schedule delays
- Limitations on required real estate at Steensby for operating equipment, stockpiling and blending
- During cold weather operation, fines produced would agglomerate and potentially contaminate the lump product.

3.4 Option 4 – Primary and secondary crushing at the Mine Site and rail to Steensby where the bulk ore is tertiary crushed and lump and fines are screened out

Similar to other options the ore will be primary crushed first, and then it will be secondary crushed in open circuit at the mine site. Only one product will be produced from secondary crushing with a CSS of 38 mm which is a bulk iron ore with P_{80} of 43 mm. The bulk ore product will be conveyed to either an on-spec or an off-spec stockpile. There will only be one off-spec stockpile in this case, made up of a lump and fines mixture. The design can take into consideration the blending requirements to produce an on-spec bulk product at the mine site if needed, based on a similar blending scheme mentioned in Option 1 and Option 2. The on-spec bulk lump and fines mixture will be reclaimed into rail cars and transported by rail to Steensby. Once at Steensby, the ore will be screened first on double deck screens having a top deck opening of 32 mm and a bottom deck opening of 6 mm. The oversize from screening will be further crushed in a tertiary crushing plant with a CSS of 32 mm to disintegrate any agglomerated fines and further crush remaining oversize bulk product, and re-circulated back to the screen feed, while the lump (-32mm to +6mm) and fines (-6 mm) produced will be stockpiled separately to produce two final lump and fines products.







The final products are stockpiled before reclaimed for ship transport. Figure 4 shows a simplified block flow diagram for Option 4.

3.4.1 Advantages

- Locating most equipment at Steensby would be better in terms of operations in one area for operation, maintainability and accommodating workforce
- Reduce stockpile numbers and stacking / reclaiming equipment required at mine site. So it has
 less diverting chutes at the mine site than of Option 1
- No need to re-screen lumps to remove fines generated through material handling
- Decouples the mine site from the rail therefore not allowing down times from upstream equipment to affect the rail schedule.

3.4.2 Disadvantages

- Fines produced would agglomerate and stick to lump, reporting to the lump product and contaminating it during thaw-freeze cycles. Testwork is needed to investigate this.
- More dust, vibration and noise, and subsequent environmental issues in Steensby compared with Option 1. This may require updated Environmental Impact Assessment licensure
- Couples the rail system to the downstream equipment. Failure in the tertiary crushing may halt the rail system
- Couples the port site crushing and screening to the downstream equipment at port
- No direct send of fines material from the railcar dumpers to the port stockpiles at Steensby
- Limitations on required real estate at Steensby for expansion of the project in the future
- Increased fines from ore breakdown of tertiary crushing and repeated handling of the bulk ore.
 The primary crushed ore needs screening to minimize generation of fines. Option 4 is compromising this critical requirement.







Crushing and Screening Relocation at Steensby Trade-off Study – Rev. 0 Mary River Project

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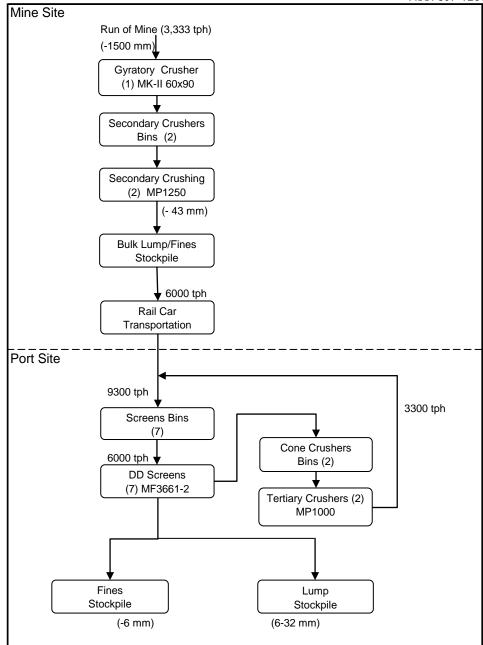


Figure 4: Option 4 block flow diagram





3.5 Design Concept in Option 4

The design concept developed in Option 4 involves only primary and secondary crushing of the ore at the mine site. Similar to Aker Kvaerner and AMEC design, the plant would be designed to accept up to 35% of fines and up to 85% of lump ore. The operation on the mine site would only consist of primary and secondary crushing, blending of ores at stockpiles (if required), and direct load out to the port. The ROM ore from the dump hopper feeds directly into the 60 in. by 89 in. primary gyratory crusher with an open side setting of 200 mm. The primary crusher discharges ore, reduced to 80% minus 180 mm into a surge hopper. Two secondary MP1000 cone crushers with a CSS of 38 mm in open circuit would produce a single bulk lump / fines product. The primary and secondary crushing would be designed to handle 3,333 tonnes per hour. The bulk ore product with P80 of 43 mm and top size of 75 mm would be conveyed to either an on-spec or an off-spec stockpile. There would only be one off-spec stockpile in this case, made up of a lump and fines mixture. The design can take into consideration the blending requirements to produce an on-spec bulk product at the mine site if needed, based on a similar blending scheme mentioned in Option 1 and Option 2. The on-spec bulk lump and fines mixture would be reclaimed into rail cars and transported by rail to Steensby. Once at Steensby, the ore would be screened on seven double deck multi-slope vibrating screens with an upper and lower deck opening size of 32 and 6 mm respectively. The oversize from screening would be further crushed in a tertiary crushing plant comprising of two MP1000 cone crushers with a CSS of 32 mm to further crush the remaining oversize bulk product from secondary crushing. The tertiary crushed ore would be re-circulated back to the screen feed bins through a chute to be installed in transfer house, while the lump (-32 mm to +6 mm) and fines (-6 mm) produced would be stockpiled separately into two final lump and fines stockpiles before reclaimed for ship transport. A simplified flow sheet of Option 4 is shown in Figure 3.

The major equipment in Option 1 and Option 4 have been summarized for comparison in Table 2. The main change in Option 4 over that of Option 1 is moving screening from the mine site to the port site and addition of tertiary crushing in the port. Consequently vibrating screens from six MF12x27DD at the mine site and six MF10x24DD at the port would be reduced to seven MF3661-2, (same class of MF10x24DD screen) at the port site. Option 4 has two less trippers, one less stacker and also less stockpile area at the mine site stockpiles than Option 1. Option 4 has two MP1000 secondary cone crushers at the mine site and two MP1000 tertiary cone crushers in the port site, instead of three MP1000 cone crushers at the mine site in Option 1. A conceptual arrangement sketch of Option 4 is shown on Figure 4 and Figure 5 for the mine and port sites. The mine site stockpiles can be parallel to the overland conveyor, decreasing conveyor lengths in Option 4.







Table 2: Major equipment in Option 1 and Option 4

Major Equipment	Option1	Option4
Mine Site		
Gyratory Crusher	(1) MK-II Superior 60-89	(1) MK-II Superior 60-89
Vibrating Screen	(6) MF12x27 DD	-
Cone Crusher (Secondary)	(3) MP1000	(2) MP1000
Tripper	(1) 1315 t/h, (2) 3200 t/h	(1) 3333 t/h
Stacker	(1) 1315 t/h, (2) 3200 t/h	(1) 3333 t/h
Reclaimer	(2) 3450 t/h	(2) 3450 t/h
Stockpiles No.	(4) two on-spec, two off-spec	(2) one on-spec, one off-spec
Port Site		
Rotary Rail Car Dumper	(2) 6000 t/h	(2) 6000 t/h
Vibrating Screen	(6) MF10x24 DD	(7) MF3661-2
Cone Crusher (Tertiary)	-	(2) MP 1000
Tripper	(1) 13800 t/h, (1) 6900 t/h	(1) 13800 t/h, (1) 6900 t/h
Stacker	(1) 6900 t/h	(1) 6900 t/h
Reclaimer	(1) 8000 t/h	(1) 8000 t/h
Stacker / Reclaimer	(1) 6900 t/h	(1) 6900 t/h

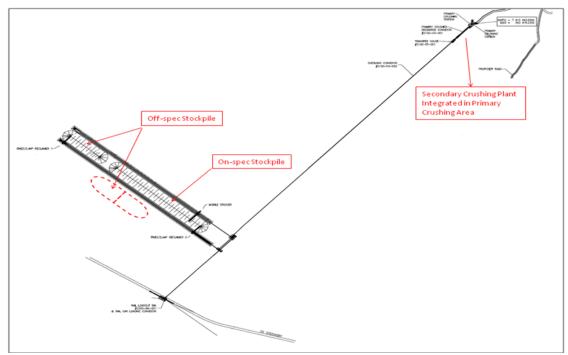


Figure 5: Proposed Configuration for Primary and Secondary Crushing Plants and Stockpiles at the Mine Site in Option4





The mine site stockpiles layout need further study as the off-spec stockpile may intersect with higher altitudes in its farther part shown in Figure 5, resulting in considerable earthwork. Also as stackers and reclaimer may not travel long distances, another alternative for the off-spec stockpile would be the dashed line stockpile shown in Figure 5. However with this new arrangement, different stacker, reclaimer and tripper configuration will be required.

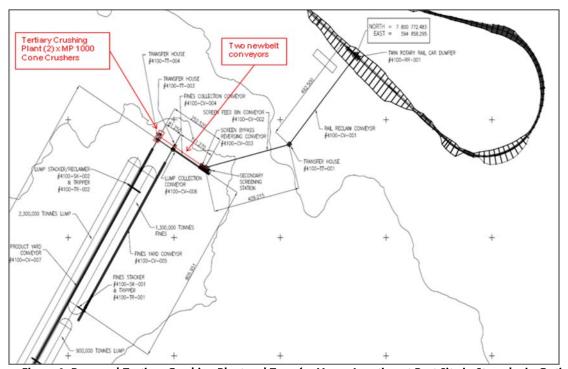


Figure 6: Proposed Tertiary Crushing Plant and Transfer House Location at Port Site in Steensby in Option4

The list of major process equipment is shown in Appendix A. Considering only the crushing and screening equipment, there is an approximate 1000 kW excessive connected power in Option 4 over Option 1. However for a more accurate estimate, the required power for material handling system, including modifications in stackers, reclaimers, belt conveyors, feeders and dust collectors in both options should also be considered.

Loading coarse iron ore into the rail cars (as in Option 3) may require special designed and strengthened railcars according to Canarail. So the reason to keep the secondary crushed product at P_{80} of 43 mm is to avoid extra costs on the rail system. Moreover 43 mm secondary crushing product size in Mary River can be handled in a single stage screening plant at the port site to produce the required lump and fines products.

3.6 Agglomeration of fines to lump in Option 4

In order to have an overall understanding of the ratio of agglomerated fines to lump due to thaw-freeze cycles at Mary River, a series of testwork need to be conducted. Since there is no standard test procedure to follow, Hatch proposed a testwork procedure to Jenike & Johanson (J&J) to investigate the agglomeration problem. The proposed test procedure comprises of two series of tests on a mixed iron ore sample. The first series of testwork comprise of only screening the mixed product, while the second series include screening and crushing the mixed product. Both series of testwork must be







conducted in an environmental chamber at below zero temperatures. The tests are intended to simulate the environmental conditions of Mary River site. It is expected that the testwork results indicate the ratio of fines sticking to the lump after screening, and also screening and crushing. Conducting the testwork require representative samples from the mine, and provision for screens and crusher in a frozen environment. According to J&J, they have an isolated environmental chamber with a capability of down to -29 °C to conduct the screening tests; however they have no crusher in their laboratories. J&J intends to use other laboratories with crushing facility and conduct the testwork in an environmental chamber. Since provision to do the testwork will take time, Hatch decided to estimate the ratio of agglomerated fines to lump in Option 4.

The Baffinland Iron Ore Project is designed to accept up to 35% of fines and up to 85% of lump ore. It is assumed that 70% of fines may be produced up to the secondary crushing stage in Option 4. Thus, in the worst case i.e. 35% fines material in the product, if 75% of the fines after secondary crushing, stacking, reclaiming, transportation by railcars, and before delivery to the primary screening at the port site, is supposed to be agglomerated to the lump due to freezing, the maximum percentage of fines stuck to the lump material will be18.4% (=70%x35%x75%).

In Option 4 there are screening and tertiary crushing at the port site in Steensby. Depending on what portion of agglomerated fines may separate from lump during screening and tertiary crushing, four different probabilities are considered and shown in Table 3.

Table 3: Estimated maximum percentage of agglomerated fines reporting to the final lump product at Steensby in Option 4

Probability of stuck fines in final lump product after screening and crushing at the port site	25%	50%	75%	100%
Maximum agglomerated fines reporting to the final lump product	4.6%	9.2%	13.8%	18.4%
Maximum agglomerated fines in the final lump product	6.6%	12.4%	17.5%	22.1%

In the worst case with just 65% final lump product, according to Table 3, 18.4% agglomerated fines to the lump, would report to the lump, which means 22.1% fines in the final lump product (Figure 7). If screening and crushing at the port could only separate 25% of the stuck fines to lump, 13.8% of fines will still remain with the final lump product; i.e. 17.5% fines in the lump product. It should be noted that there is a possibility of agglomeration between new fines and lump produced during tertiary crushing, and also due to screening deficiency some additional fines may report to the final lump product which these have not been considered in this estimate.





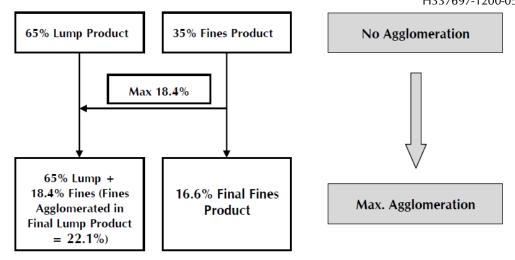


Figure 7: Estimated maximum fines agglomerated to the final lump product

To estimate monthly tonnage of stuck fines to lump ore, the maximum and minimum daily temperature records from Pond Inlet which is located 160 km north of Mary River were used. These records are based on the 20-years climatic data from the National Climate Data and Information Archive of Canada 1971-2000. It was assumed that the temperature variations in Steensby (where the screening and tertiary crushing equipment will be installed), follow more or less a similar pattern as the Pond Inlet (Table 4). Based on the data it is seen that even in July which is the warmest month of year, there are 3.9 out of 31 days with a minimum temperature < =0°C. In January for example 30.9 out of 31 days, the maximum temperature is below 0°C. However, even in January, February, March and April above 0°C maximum temperature has been recorded. Generally by extending the climatic pattern of Pond Inlet to Mary River / Steensby it can be expected that from May to October there are temperature variations from plus to minus degrees during 24 hours a day. However daily based maximum and minimum temperature records from Mary River / Steensby can be very useful in anticipating the potential sticking of fines.





Table 4: Monthly temperature variations in Pond Inlet

POND INLET A	POND INLET A*											
Temperature:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Average (°C)	-32.4	-34.1	-30.3	-22.1	-9.9	1.8	6	4.2	-1.4	-11.4	-22.4	-28.7
Standard Deviation	3.5	4.1	2.4	2.4	2.5	1.5	1.3	1.1	1.6	3.1	3.8	3.2
Daily Maximum (°C)	-28.8	-30.6	-26.4	-17.7	-5.8	4.7	9.8	7.2	1.2	-8	-18.5	-25
Daily Minimum (°C)	-35.9	-37.5	-33.9	-26.5	-13.9	-1.1	2.1	1.2	-4	-14.7	-26.1	-32.4
Days with Max	imum To	emperat	ure:									
<= 0 °C	30.9	28.3	31	29.9	26.4	2.9	0	0.11	11.4	29.6	30	31
> 0 °C	0.13	0.05	0.04	0.14	4.7	27.1	31	30.9	18.6	1.5	0	0
Days with Mini	Days with Minimum Temperature:											
> 0 °C	0	0	0	0	0.08	12	25.5	19.8	3.4	0.04	0	0
<= 0 °C	29.9	27.3	30	28.7	29.4	16.8	3.9	9.6	24.8	29.3	28.7	29.6

^{*}Source: http://www.climate.weatheroffice.gc.ca/climate_normals/station_metadata_e.html?StnId = 1774

However thaw and freeze can also occur when frozen bulk material flows through a storage container. In bulk containers the particles are subjected to compressive and shear forces. These can cause the ice on the particles surfaces to melt. As the bulk solid flows further, contact pressure drops again and the water refreezes. Mixed frozen lump and fines can be more prone to agglomeration due to compressive forces. For reducing the risk of agglomeration, it is recommended that fines to be separated from lump as much as possible in the production process. Combining climatic data with the maximum percentage of agglomerated fines to lump results in Figure 5 and Figure 8, showing the agglomerated fines to lump tonnage in different months of the year.







Table 5: Agglomerated fines to lump in different months of year

Month	Agglomeration Risk (day/month)	Option 4 with maximum agglomeration%	Option 4 - Fines Agglomerated (t)
January	1	22%	14,000
February	1	22%	14,000
March	1	22%	14,000
April	1	22%	14,000
May	5	22%	68,000
June	12	22%	162,000
July	4	22%	54,000
August	10	22%	135,000
September	12	22%	162,000
October	2	22%	27,000
November	0	22%	0
December	0	22%	0
Total	49		664,000

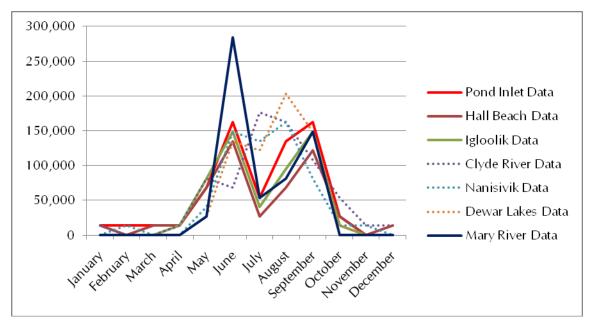


Figure 8: Estimated maximum fines agglomerated to the final lump product in different months of year





Figure 8 shows the maximum estimated agglomeration of fines to lump in tons in different month of year based on available weather data in Baffinland Island. The graphs were plotted according to climatic data from weather stations around Baffinland Island including Pond Inlet, Hall Beach, Igloolik, Clyde River, Nanisivik, Dewar Lakes and Mary River (Figure 9). No long term climatic data for Mary River and Steensby was found. The only available daily maximum and minimum temperature data for Mary River, used for the estimate are from years 1963 to 1965, including mostly April to September months with some gaps in between. According to Figure 8, two groups of climatic pattern affecting the agglomeration of fines to lump are recognisable. The first group, including Pond Inlet, Hall Beach and Igloolik and Mary River, has two peak points with two increasing agglomeration period risk around June and September months. Steensby climatic pattern is expected to follow the first group pattern shown by solid lines in Figure 8. The second group including Clyde River, Nanisivik and Dewar Lakes, shown by dotted lines in Figure 8, have almost one peak point with maximum agglomeration period risk around August-September.

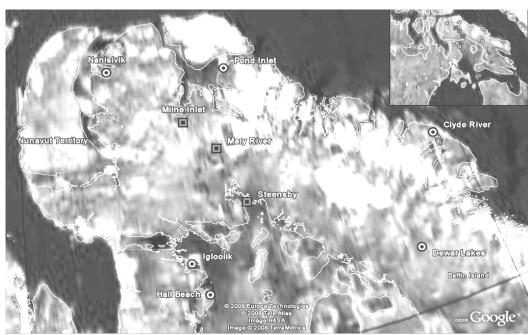


Figure 9. Weather stations around Baffinland Island

By comparing the estimated figures in Table 3 with the lump and fines iron ore contract specifications from Baffinland Iron Mines and other suppliers (see Appendix B), it can be seen that in order to meet the buyers' specifications for Mary River lump iron ore product, the maximum agglomerated fines in final lump product should be maintained well below 4%. Thus the testwork results should confirm the separation of at least 75% of agglomerated fines from lump during screening and tertiary crushing to fulfil the buyers' requirement of 4% fines.





3.7 Agglomeration of fines to lump – Mitigation Plans

Mitigation Plans were defined in order to reduce the impact of fines sticking to the lumps. These plans can be put in place at a later date, well after the mine is started. They will give options to the operators to minimize fines content in Lump product. Graphical representations of these plans are included in Appendix III. These plans are:

At Mary River Mine Site:

- Minimise fines generation: use optimised blast pattern; eliminate transfer points;
- Add primary screening stage before the stockpiles. Design of Option 4 will allow the installation at a later date, of a primary screening stage before the stockpiles. This will bring the risk of fines sticking to the lumps at an equal or at a lower % of fines sticking than the ones of Option 1, since fewer fines will be generated at Mary River with Option 4.

At Steensby:

- Spread frozen fines to lumps on the lump stockpile
- Store and reprocess frozen fines through screens and tertiary crushers on Steensby Island.
- Store and ship the frozen fines in a dedicated ship
- Store, ship and screen at destination







4. Capital and Operating Costs

4.1 Capital Cost

Option 4 will reduce the Project Direct Cost of at the least -60M, distributed as per following:

- A reduction of 100M by removing the primary screening and the secondary close circuit crushing buildings at the Mine Site.
- A reduction of 20M by removing two stackers and one stacker runway at the Mine Site.
- An addition of 25M for the new open circuit crushing building close to the primary crusher.
- An addition of 35M for the new tertiary crusher building and one extra screen at Steensby.

In addition to the direct cost, a reduction in the indirect cost of 40M should be considered. That will bring a total cost reduction in the order of 90 to 100M for the application of the Option 4.

However CAPEX cost savings need to be evaluated more accurately.

4.2 Operating Costs

- Option 4 will required less electrical power at the Mine site. An estimated reduction of 1,500kW will apply. This means less fuel to transport to the mine and smaller power plant required at the mine site.
- Option 4 will required less maintenance at the mine. This means less spare parts and consumables parts to be carried to the mine site.
- Option 4 will required less man power at the mine. This means smaller accommodation and less passenger transport to the mine site.
- Having fewer buildings at the mine means less access road, less road maintenance and less snow removal at the mine site.

However OPEX cost savings need to be evaluated more accurately.

4.3 Other Cost Reduction opportunities:

- More cost reduction can by apply when using Option 4. As per example: the Gyratory discharge
 pocket can be smaller. A large discharge conveyor can be put in place, this conveyor will feed
 directly the 2 truck loads secondary crusher feed bin located nearby. This will minimise the
 required excavation and cut at the primary crushing stage.
- The stockpile footprint is smaller with only one product at the site. Pile arrangement can be modified and stockpiles can be brought with an alignment North-South from Mine to train loadout. In this area the ground is better, there is less sand and silt to be removed, and piles to support stacker and reclaimer runway could be minimise.

These other cost reduction may be considered at a later project engineering phase.







5. Environmental consideration

- Option 4 minimises the footprint at the mine site; it requires less real estate.
- Option 4 requires less power at the mine site. This means less fuel needs to be railed to the mine.
- More dust and noise are generated at Steensby. A dust collecting system will be installed at the
 tertiary crushing and at the screening plants. Conveyors between tertiary crushing building and
 screening building are enclosed.
- Vibration made by tertiary crusher may have impact on the sea mammals.
- Option 4 may require an updated Environmental Impact Assessment licence.







6. Conclusion and Recommendation

As a result of this review, Option 4 locates most operating equipment at Steensby as a centralized location, which is better in terms of operations in one area for maintainability; minimizes stockpile numbers and stacking / reclaiming equipment required at the mine site; decouples the mine site activities from the rail and allows a buffer from any down-time associated from up-stream equipment which would affect the rail schedule; has only one off-spec stockpile, made up of a lump and fines mixture in the mine site, simplifying the process operation at the mine site; and will reduce operating labour requirement at Mary River. Smaller accommodation at Mary River will result in less fuel and power consumption. This also would impact on less transport and tank farm at Mary River. Mitigation plans to avoid fines sticking to the lumps in Option 4 can be put in place at a later date, well after the mine is started if fines freezing to the lumps are a concern in the future. These plans will give opportunities to the operators to minimize fines content in lump product.

Option 4 will not produce fines product which can directly be sent from the mine site to the port stockpiles at Steensby as is predicted in Option 1. Another concern is the coupling of port site crushing and screening to the downstream equipment at the port, and coupling the rail system to the downstream tertiary crushing equipment in this option. And, there are limitations on required real estate in the port island at Steensby. AMEC's layout for expanding the stockpiles at Steensby was based on 30 Mt/a production which is different with Option 1 and Option 4 layouts at Steensby. As lump iron ore has a higher value compared with fines, the most important concern in Option 4 is agglomeration of fines to lump which may affect the quality of final lump product. Predicting the behaviour of frozen agglomerated fines within lump is complicated and requires testing, however to have an overall understanding of the ratio of agglomerated fines to lump, Hatch made an estimation for this ratio in Option 4. Depending to what portion of agglomerated fines may separate from lump during screening and tertiary crushing, four different probabilities were considered. Therefore with a minimum of 65% final lump product, with natural moisture content of the ore, in the worst case there would be about 22% fines agglomerated to the lump.

In order to meet the buyers' contract specifications of Mary River lump iron ore product, the maximum agglomerated fines in final lump product should be maintained well below 4%. Thus results from testwork planned to be conducted on Mary River samples should confirm the separation of at least 75% of agglomerated fines from lump during screening and tertiary crushing to make Option 4 process wise feasible. However even a very well designed fines agglomeration test, due to numerous variable involved, can hardly be taken as a test protocol covering all conceivable variable that could be encountered in real situation. It should be noted that both Aker Kvaerner and AMEC proposed Option 1 in the previous design work for Mary River Project. The other studied options were ruled out of further design work either because of the possibility of agglomeration of fines to lump due to alternating thaw-freeze cycles, or due to risk to the rail system and subsequent higher capital and operating costs. Hatch does not recommend compromising the quality of the Mary River lump product. Therefore Hatch's recommendation for the Mary River Project is optimised Option 1. Hatch also suggests developing Option 4 simultaneously with the development of optimised Option 1.







Items that are recommended to be considered for optimisation of Option 1 are listed below:

- Review the storage requirements specially at Mary River (bins, stockpiles)
- Optimise the primary and secondary screens design and arrangement at Mary River and Steensby
- Better define blending (mixing) concept for the Mary River stockpiles
- Relocate secondary crushers closer to the Mary River stockpiles
- Material handling simplifications to minimize fines generation, revisiting the cut-off point for the
 fines allowed in the lumps, associated penalties and then determine if in fact we need secondary
 screens or we can at least defer them if we can't confirm their completely elimination
- Evaluate if only a part of the lump can be secondary screened at Steensby requiring fewer screens
- Revisit operating cost of secondary screens based on the probability of their full utilization







Appendix A:
Major Equipment Connected Power in Option 1 and 4





Major Equipment Connect Power in Option 1

Major Process Equipment	Nominal Capacity	Qty	Unit	Power kW/Unit	kWh	Remarks
Mine Site						
Gyratory Crusher	4360 t/h	1	each	600	600	MK-II Superior 60-89
Vibrating Screen	1666 t/h	6	each	55	330	XXH duty, double deck MF 12x27
Cone Crusher (Secondary)	1600 t/h	3	each	750	2250	MP1000
Tripper	1315 t/h	1	each			Main Motor
		1	each			Creep Motor
Tripper	3200 t/h	1	each			Main Motor
		1	each			Creep Motor
Tripper	3200 t/h	2	each			Main Motor
		1	each			Creep Motor
Stacker	1315 t/h	1	each			Main Motor
		1	each			Creep Motor
		8	each			Traversing Drive Motors
		2	each			Rail Clamps
		2	each			Slewing Drive Motors
		2	each			Luffing Drive Motors
		1	each			Power Cable Reel
		1	each			Control Cable Reel
Stacker	3200 t/h	1	each			Main Motor
		1	each			Creep Motor
		8	each			Traversing Drive Motors
		2	each			Rail Clamps
		2	each			Slewing Drive Motors
		2	each			Luffing Drive Motors
		1	each			Power Cable Reel
		1	each			Control Cable Reel
Stacker	3200 t/h	1	each			Main Motor
		1	each			Creep Motor
		8	each			Traversing Drive Motors
		2	each			Rail Clamps





Major Process Equipment	Nominal Capacity	Qty	Unit	Power kW/Unit	kWh	Remarks
		2	each			Slewing Drive Motors
		2	each			Luffing Drive
						Motors
		1	each			Power Cable Reel
		1	each			Control Cable Reel
Reclaimer	3450 t/h	2	each			Main Motor
		2	each			Creep Motor
		16	each			Traversing Drive Motors
		4	each			Rail Clamps
		4	each			Slewing Drive Motors
		4	each			Luffing Drive Motors
		2	each			Power Cable Reel
		2	each			Control Cable Reel
		2	each			Wheel Drive
Stockpiles No.		4				two on-spec, two off-spec
Port Site						·
Rotary Rail Car Dumper	6000 t/h	2	each			
Vibrating Screen		6	each	30	180	XXH duty, double deck MF 10x24
Cone Crusher (Tertiary)	-					
Tripper	13800 t/h	1	each			
	6900 t/h	1	each			
Stacker	6900 t/h	1	each			
Reclaimer	8000 t/h	1	each			
Stacker/Reclaimer	6900 t/h	1	each			
Total connected power with handling (kW)	out considering material				3360	







Major Equipment Connected Power in Option 4

Major Process Equipment	Nominal Capacity	Qty	Unit	Power kW/Unit	kWh	Remarks
Mine Site						
Gyratory Crusher	4360 t/h	1	each	600	600	MK-II Superior 60-89
Cone Crusher (Secondary)	1900 t/h	2	each	937	1874	MP1250
Tripper	1315 t/h	1	each			Main Motor
		1	each			Creep Motor
Tripper	3200 t/h	1	each			Main Motor
		1	each			Creep Motor
Tripper	3200 t/h	2	each			Main Motor
		1	each			Creep Motor
Stacker	3200 t/h	1	each			Main Motor
		1	each			Creep Motor
		8	each			Traversing Drive Motors
		2	each			Rail Clamps
		2	each			Slewing Drive Motors
		2	each			Luffing Drive Motors
		1	each			Power Cable Reel
		1	each			Control Cable Reel
Stacker/Reclaimer	3200 t/h	1	each			Main Motor
		1	each			Creep Motor
		8	each			Traversing Drive Motors
		2	each			Rail Clamps
		2	each			Slewing Drive Motors
		2	each			Luffing Drive Motors
		1	each			Power Cable Reel
		1	each			Control Cable Reel
Reclaimer	3450 t/h	1	each			Main Motor
		1	each			Creep Motor
		8	each			Traversing Drive Motors
		2	each			Rail Clamps
		2	each			Slewing Drive Motors
		2	each			Luffing Drive Motors
		1	each			Power Cable Reel







Crushing and Screening Relocation at Steensby Trade-off Study – Rev. 0 Mary River Project

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Major Process Equipment	Nominal Capacity	Qty	Unit	Power kW/Unit	kWh	Remarks
		1	each			Control Cable Reel
		1	each			Wheel Drive
Stockpiles No.		2				One on-spec, One off-spec
Port Site						
Rotary Rail Car Dumper	6000 t/h	2	each			
Vibrating Screen	MF3061-2	7	each	55	385	XXH duty, double deck MF3061-2
Cone Crusher (Tertiary)*	1600 t/h	2	each	750	1500	MP1000
Tripper	13800 t/h	1	each			
	6900 t/h	1	each			
Stacker	6900 t/h	1	each			
Reclaimer	8000 t/h	1	each			
Stacker/Reclaimer	6900 t/h	1	each			
Total connected power withou (kW)	t considering material handling				4359	

^{*}Two new belt / apron feeders and two new belt conveyors should be also considered for the tertiary crushers. Also one new belt / apron feeder for the additional screen, and modification in dust collectors in the port site.







Appendix B: Lump and Fine Iron Ore Contract / Shipment Specifications





between 0.20-0.40%) Blending Marra Mamba & Brockman ores (Mn

between 0.20-0.40%)

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Crushing and Screening Relocation at Steensby Trade-off Study – Rev. 0 Mary River Project

based upon variance of shipped product specifications

-6.3mm 13% max

-150micron 28% maximum

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Conditions common to all contracts (actual shipment specifications may vary)

Ore types	Country	Product	Fe	S	P	SiO2	AI2O3	Others	Moisture	Size	Notes
											Mn not in guarantee,
											but in product spec
CVRD-Tubarao A	Brazil - SSystem	lump	66/64	0.03	0.08	3.5	1.5	0.15	6	-12.5mm 45% maximum	sheets as 0.3% Mn
											In product spec sheets
CVRD-SFJ	Brazil - SSystem	fines	66.5/65.0	0.03	0.035	3.8	0.8	0.15	6	+6.3mm 13% maximum; -150micron 42% maximum	as 0.2% Mn
CVRD-Carajas	Brazil - NSystem	lump	66.5	0.02	0.065	1.0	1.5	0.15	5	-6.3mm 14% max	0.5% Mn max
CVRD-Carajas	Brazil - NSystem	fines	66.0	0.02	0.065	1.7	1.7	0.15	9	+6.3mm 10% maximum; -150micron 20% maximum	0.8% Mn Max
Hamersley Iron	Pilbara-MM-B Blend	lump	64/62	0.05	0.06	5.0	2.0	0.15	3	-6.3mm 10.5% max	Blending Marra Mamba & Brockman ores (Mn between 0.20-0.40%)
Hamersley Iron	Pilbara-MM-B Blend	fines	64/61	0.05	0.07	7.0	2.5	0.15	6	-150micron 28% maximum	Blending Marra Mamba & Brockman ores (Mn between 0.20-0.40%)
BHP Billiton	Mt Newman	lump	64/62	0.04	0.06	5.0	2.0	0.15	3	-6.3mm 13% max	Blending Marra Mamba & Brockman ores (Mn between 0.20-0.40%)
BHP Billiton	Mt Newman	fines	60/59	0.06	0.07	7.0	3.0	0.15	6	-150micron 28% maximum	Blending Marra Mamba & Brockman ores (Mn between 0.20-0.40%)
Penalties				\$0.10/0.01%	\$0.30/0.01%	\$0.10/1%	\$0.50/1%			~\$0.50-1.5 for each 1% in excess of contract amount	

Source: Tex Report Iron Ore Manual 2000, 2004, 2006

Shipped Products (Specification sheets)

Ore types	Country	Product	Fe	S	P	SiO2	AI2O3	Others	Moisture	Size	Notes
CVRD-Tubarao A	Brazil - SSystem	lump	65.0	0.006	0.065	2.5	20	0.15	4.5	+12.5mm 82% maximum	Mn 0.3% Mn
											In product spec
CVRD-SFJ	Brazil - SSystem	fines	66.0	0.005	0.027	3.6	0.7	0.15	4.8	+6.3mm 9% maximum; -150micron 27% maximum	sheets as 0.2% Mn
CVRD-Carajas	Brazil - NSystem	lump	64.4	0.006	0.05	1.8	23	0.15	5	-6.3mm 17% max	0.75% Mn
CVRD-Carajas	Brazil - NSystem	fines	67.0	0.006	0.033	0.9	1.0	0.15	8	+6.3mm 10% maximum; -150micron 16%	0.5% Mn
Hamersley Iron	Pilbara-MM-B Blend	lump	64/62	0.05	0.06	5.0	2.0	0.15	3	-6.3mm 10.5% max	Blending Marra Mamb & Brockman ores (Mn between 0.20-0.40%)
Hamersley Iron	Pilbara-MM-B Blend	fines	64/61	0.05	0.07	7.0	2.5	0.15	6	-150micron 28% maximum	Blending Marra Mamb & Brockman ores (Mr between 0.20-0.40%)
											Blending Marra Mamb & Brockman ores (Mn

2.0

3.0

0.15

0.15

3

BHP Billiton Source: Company Publications

BHP Billiton

Contract conditions

Contract conditions											
Ore types	Country	Product	Fe	S	P	SiO2	Al2O3	Others	Moisture	Size	Notes
Baffinland	Canada-Mary River	lump	66	0.13	0.04	3.2	1.3	0.15	2	-6.3mm 8% max	Mn Maximum 0.20%
Baffinland	Canada-Mary River	fines	66	0.13	0.04	3.2	1.3	0.15	4	+6.3mm 10% maximum; -150micron 12% maximum	Mn Maximum 0.20%
Sale Products (first 10 years)											
Ore types	Country	Product	Fe	S	P	SiO2	Al2O3	Others	Moisture	Size	Notes
D 66 1	Constant March Discours			0.4	0.00	2.7	10	0.15	4	-6.3mm 4% max	Mn Maximum 0.12%
Baffinland Baffinland	Canada-Mary River	lump	66	0.1	0.03	2.1		0.15		-6.3mm 4% max	Mn Maximum 0.12% Mn Maximum 0.12%

Baffinland Canada-Mary River fines

Mt Newman

Mt Newman

64/62

60/59

fines

0.04

0.06

0.06

0.07

5.0

7.0





Crushing and Screening Relocation at Steensby Trade-off Study – Rev. 0 Mary River Project H337697-1200-05-124-0001

Appendix C: Crusher at Steensby - Fines Generation and Risk Mitigation

Baffinland

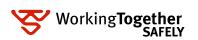
TOS 5000-1 Crusher at Steensby TOS 5000-2 Base Case Optimisation



June 28, 2011

Safety Share



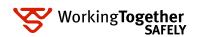








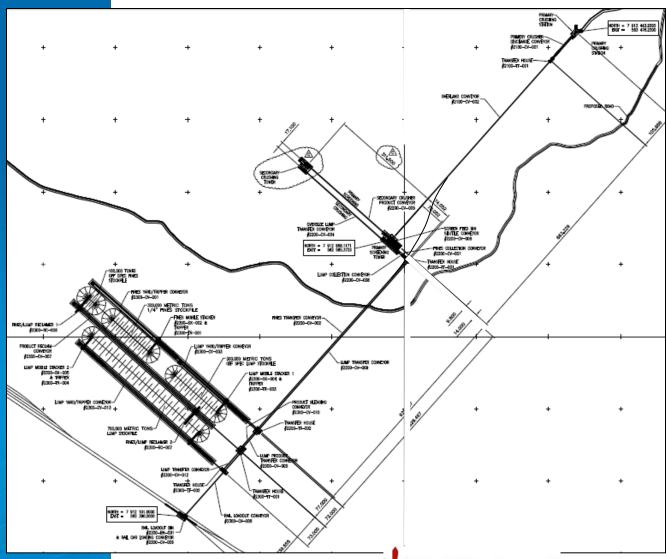
- 1- General arrangement Option4 (one product at the mine site)
- 2- Fines generation and Risk Mitigation
- 3- General Arrangement Option 1 Optimization
- 4- Capex and Opex consideration
- 5- Varia

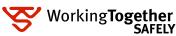






Option 1 at Mine Site

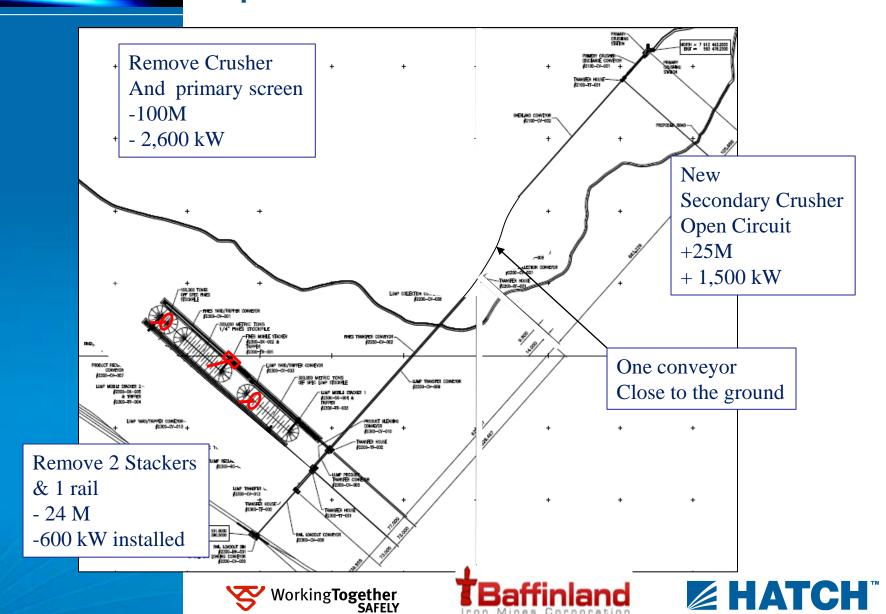




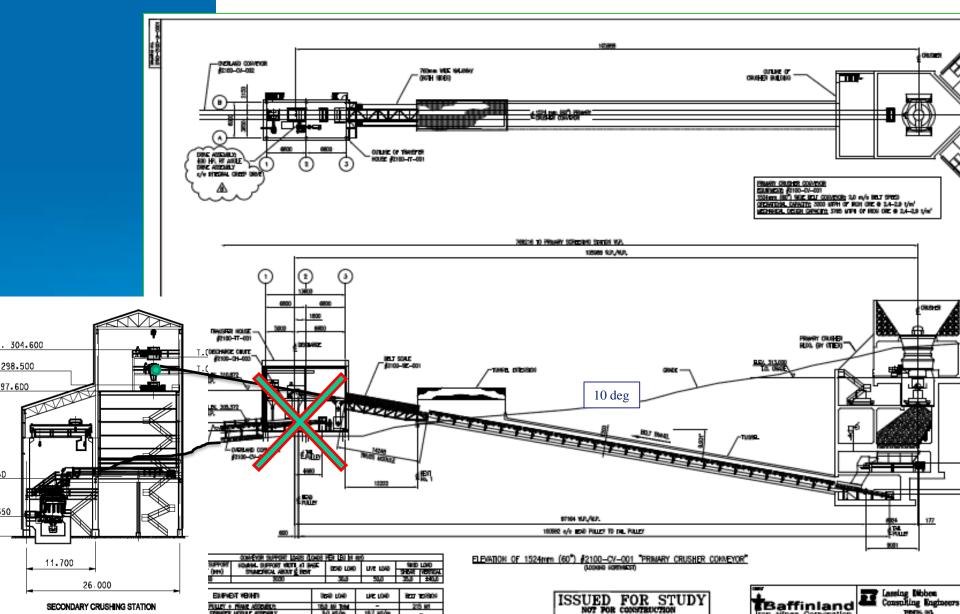


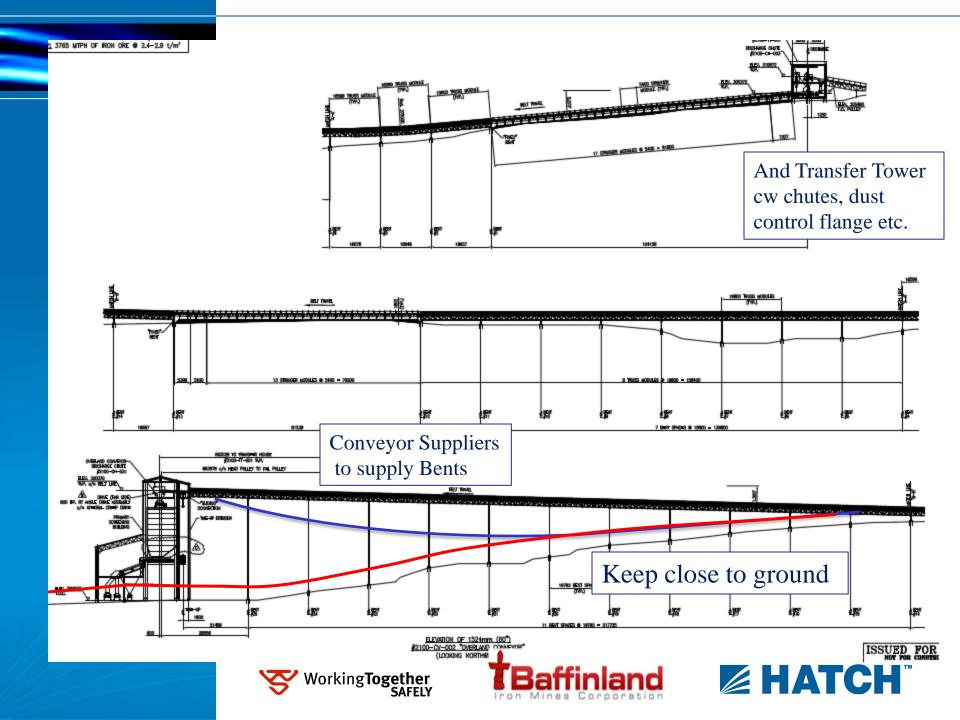


Option 4 at Mine Site



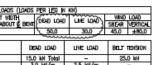
Option 4 – secondary crushing

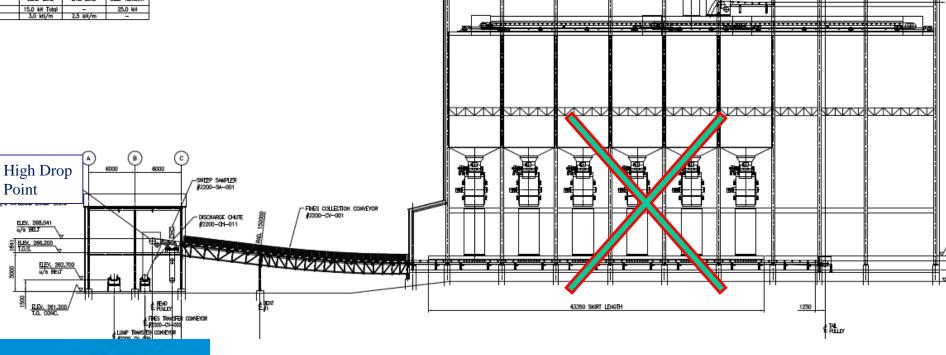


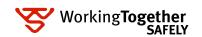


Mary River - Mine Site

PRIMARY SCREENING TOWER



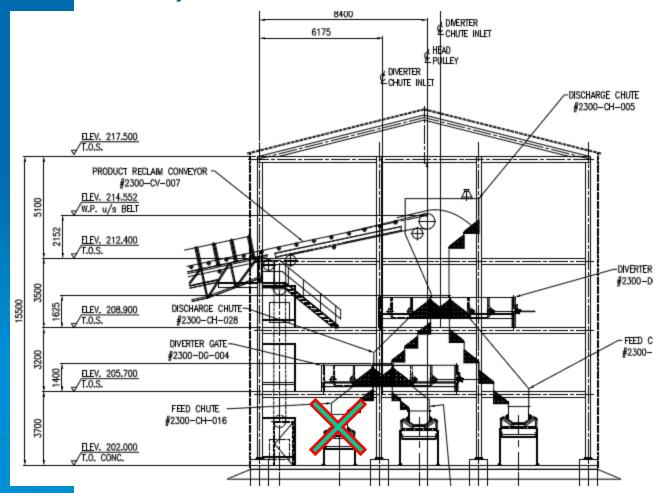


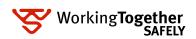






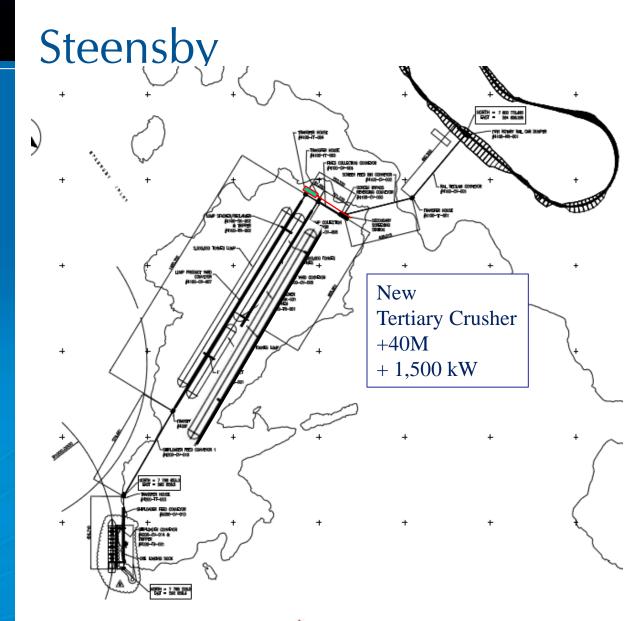
Mary River - Mine Site

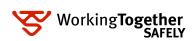








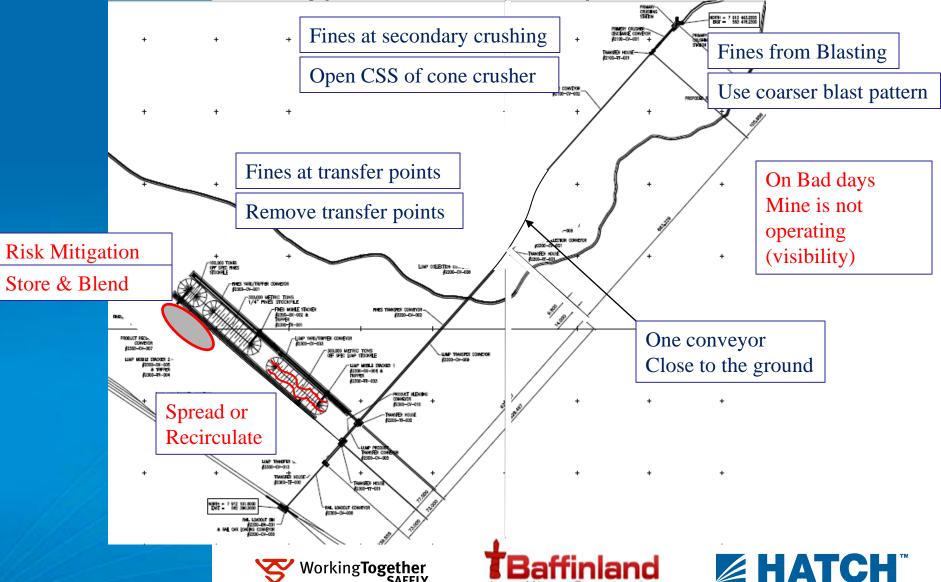




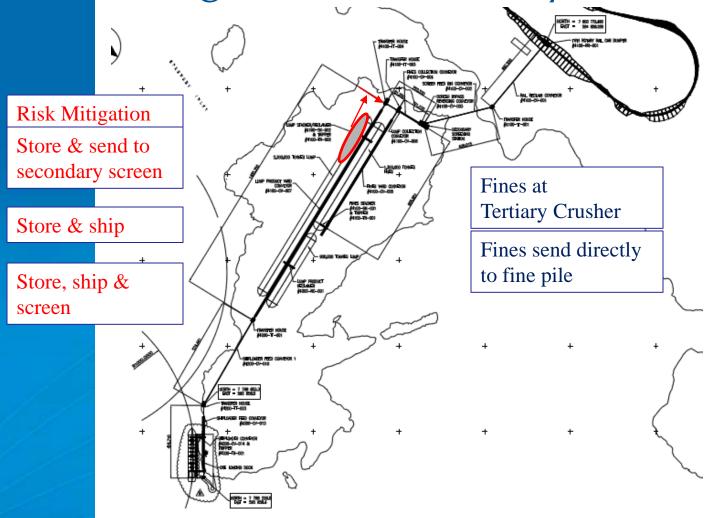


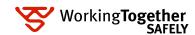


Fines Generation and risk mitigation at Mary River



Fines Generation and risk mitigation at Steensby

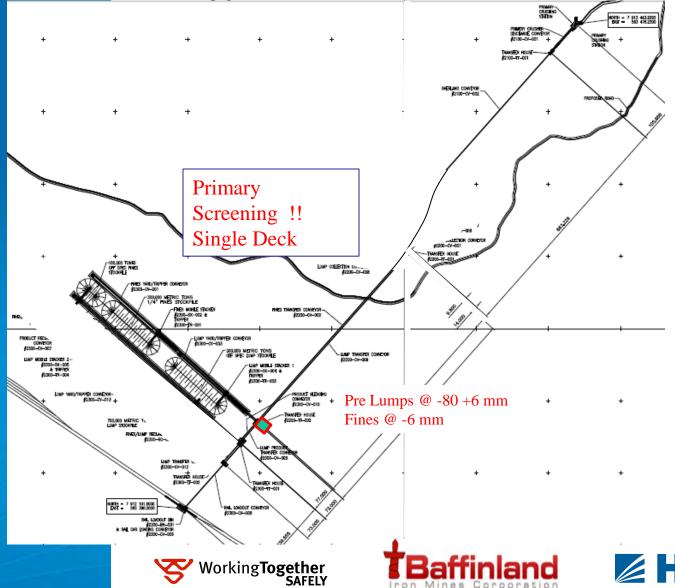






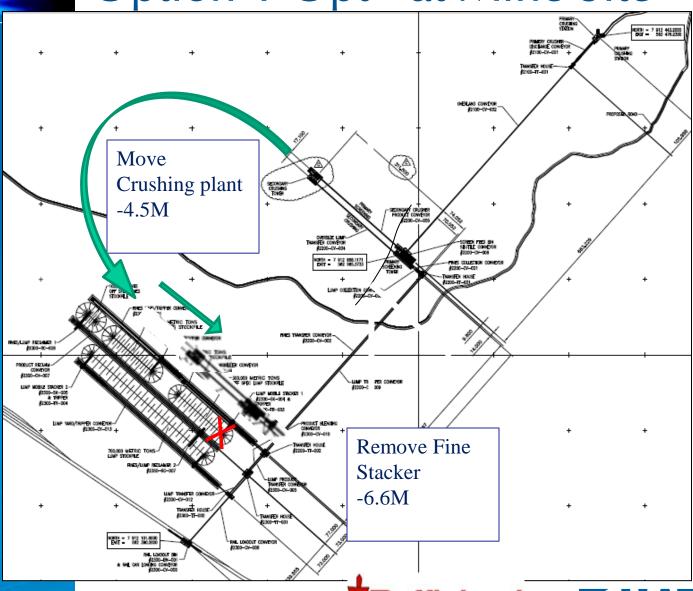


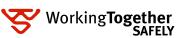
The Ultimate Fines Sticking Mitigation





Option 1 Opt - at Mine Site



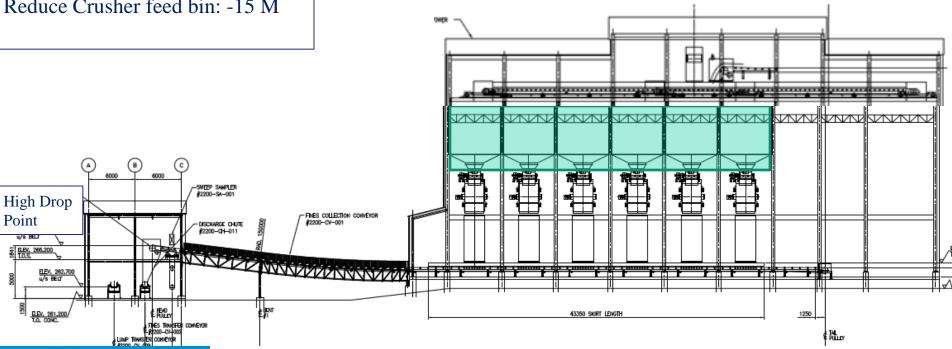


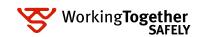




Option 1 Opt - at Mine Site

Reduce Screen feed bin: - 20 M Reduce Crusher feed bin: -15 M



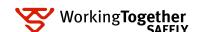






Options Summary

Options	Capex Saving * (M\$)	Capex Saving * %	Opex Impact	Risk		
Option 1 Base Case	-	-	-	No Stacking Redundancy		
Option 4	- 95	-10	-Fuel transport, -Labor transport -Consummables management & transport	-Fines Sticking -Environmental at Steensby		
Option 4 RM	+ 55 (Net -40)	-4	-Fuel Transport			
Option 1 Opt.	-78	-8	-	No Stacking Redundancy		
	* Capex Saving based on Total Process & Mat Handling Cost of \$976M					







Our Recommandation

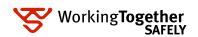
Develop Option 1 Opt

But don't Hit the Wall ...!

September

Option 4









Our Recomma

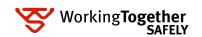
January

Develop Option 1 OPT

But don't Hit the wall











Varia

