Analysis of the Opportunity to Increase the Capacity of the Line Creek Processing Facility

by

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Dedication

To my wife Cathy, I could not have done this without your support. I truly appreciate everything you make me do and the person you are.

Today you are You, that is truer than true. There is no one alive who is Youer than You.

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List of Acronyms

$/t	Dollars per tonne
831	Standard grade metallurgical coal
833	Thermal coal
835	Eagle grade metallurgical coal
BCR	Benefit to cost ratio
BHP	Australian multinational mining company
BRN	Burnt ridge north pit
BRX	Burnt ridge extension pit
CC	Clean coal
Cdn	Canadian
CMO	Coal Mountain Operations
CRO	Cardinal River Operations
CTPH	Clean coal tonnes per hour
c/v	Conveyor
EVO	Elkview Operations
FCC	Fine coal classifying cyclone
FRO	Fording River Operations
GDP	Gross domestic product
GHO	Greenhills Operations
HMC	Heavy media cyclone
IRR	Internal rate of return
km	Kilometer
LCO	Line Creek Operations
M	One million
Met	Metallurgical coal
mm	Millimeter
Mmtcc	One million metric tonnes of clean coal
mtcc	Metric tonnes of clean coal
MTM	Mount Michael pit
NG	Natural gas
NGO	Non-government organization

NPV	Net present value
O/F	Overflow
Op days	Operating days
Q1	First quarter of the year
Ref	Refuse
RTPH	Raw coal tonnes per hour
SBC	Screen bowl centrifuge
SWOT	Strengths, weaknesses, opportunities and threat analysis
TPH	Tonnes per hour
U/F	Underflow
WOC	Water only cyclone
WS	12 hour work shift

Glossary

Anionic flocculant	A chemical that aids in separating solids from water in a thickener
Appropriation requisition	The process by which capital money spending is approved
Cable belt	The physical equipment utilized to transport raw coal from the mining area to the Processing facility
Capital cost	Money spent in order to improve or replace an asset in excess of routine repairs
Cationic flocculant	A chemical that aids in separating solids from water in a thickener
Clarified water	Water that is used in the metallurgical and thermal plant in order to separate the coal from the refuse
Coal recovery	Percentage of in pit raw coal extracted from the seam compared to the predicted volume of coal to be extracted
Cape vessel	A vessel that is too big to fit through the Panama Canal
Clean coal	The final product of either the metallurgical or the thermal plant
Coal Business Unit	The collection of all the mining operations in Teck that produce clean coal
Coarse circuit	A collection of physical equipment that processes coal larger than 0.5 mm
Eagle coal	A brand of coal that has a characteristic high volatile matter component
Electric arc furnace	Equipment used in the process to manufacture steel
Fines circuit	A collection of physical equipment that processes coal smaller than 0.5 mm
Fixed cost	An operating cost that is fixed, regardless of the total clean coal produced
Froth crowder	A physical piece of equipment that reduces the cross sectional area of the top of a flotation cell. The purpose is to force more material to the product discharge of the flotation cell
Greenfield operation	A potential mining property which has not begun to be developed

Headings	When a shovel is digging, the vertical plane is the heading
Heavy equipment	Large equipment used in the mining process
Hydrophobic	Repels water
Light vehicle	A pick-up truck or other similar sized vehicle
Line stand	The device which the pulleys on the cable belt are mounted to
Magnetite	A solid that is mixed with water and is used in the coarse circuit to modify the final product quality
Metallurgical Plant	A collection of equipment utilized to produce either metallurgical or thermal clean coal. Though it is primarily used to produce metallurgical coal
Mine life	The duration of the operating mine under the current rates of production as outlined in the Life of Mine document for Line Creek. The current end of mine life is 2036
Operating cost	Money spent in order to mine and process clean coal including items such as labour, repair parts, consumables, power and natural gas
Panamax vessel	A vessel that is small enough so that it is able to travel through Panama Canal
Porter's Five Forces Model	An analysis used to determine the strategic environment
Raw coal	Material that is used as input to either the metallurgical or the thermal plant
Refuse	The waste product from either the metallurgical or the thermal plant
Standard coal	A brand of coal that has a characteristic low volatile matter component
Thermal dryer	A vessel that uses natural gas as a heat source to evaporate water from the clean coal
Thermal Plant	A collection of equipment utilized to produce only thermal coal
Total moisture	The summation of all the water present in the clean coal represented as a percentage
Unit cost	The total cost per tonne of clean coal produced
Variable cost	An operating cost that increases or decreases in proportion to the amount of clean coal produced

Executive Summary

There is an opportunity to decrease the unit operating costs of the Line Creek Processing Facility, while increasing the throughput and maintaining product quality. The current bottleneck for clean coal production at Line Creek is 3.5 million metric tonnes of clean coal (Mmtcc) per year. An analysis of the metallurgical coal market yielded an environment that is not attractive for new entrants into the Elk Valley. Two key bottlenecks are identified and analyzed. The 4 Mmtcc bottleneck represents a need of $4.5M in capital money in 2016. The second bottleneck at 5 Mmtcc requires $4.5M of capital dollars in 2016 and $105.5M capital dollars in 2017. The NPV analysis showed a BCR of 31.4 for the 4 Mmtcc scenario over a 10 year period and a BCR of 2.2 for the 5 Mmtcc scenario over the same period. This calculation assumed a static coal price of $122 Cdn. Considering a period of coal selling price growth over the 10 year time frame, the gap is similar with the BCR for the 4 Mmtcc scenario at 55.8 and the BCR for the 5 Mmtcc scenario at 5.1. For the success of this opportunity, there must be no acute or cumulative negative effects to the environment or the communities of interest.

In conclusion, the recommendation of the analysis is to proceed with the expansion of the Line Creek Processing Facility to an annual operating capacity of 4 Mmtcc. Line Creek can realize an increase in annual production, a decrease in total operating unit costs, and an increase in the 10 year net present value of the operation along with a strong benefit to capital cost ratio by upgrading the heavy media wash plant circuit. The 4 Mmtcc option is represents the most stable low risk option to elevate the value of the Line Creek Operation asset for Teck.

A full environment scan of the increase to 4 Mmtcc is required to ensure that Teck maintains its social and environmental licence to operate in the Elk Valley.

Chapter 1.

Introduction

There is an opportunity to decrease the unit operating costs of the Line Creek Operations, while increasing the throughput and maintaining product quality. The current bottleneck for clean coal production at Line Creek is 3.5 million metric tonnes of clean coal (Mmtcc) per year. A combination of technical, infrastructure, logistics and market conditions make up the existing production limit. An analysis using Porter's (Augmented) Five Forces Model yielded an industry that is not attractive for new entrants. This further makes internal growth within the Teck Coal existing operations a more executable strategy. A bottleneck analysis generated significant operating step changes. The economic evaluation of the incremental step changes in production yielded a clear path forward when production expansion is executed. Worldwide demand and metallurgical coal price will be the driving force for future annual production increases for Line Creek and Teck Coal.

Chapter 2.

Line Creek Processing Plant Background

Raw Coal Processing

The raw coal processing begins at the mine truck dump. The raw coal is sized down to minus 200 mm in the sizer. The raw coal is conveyed from the mine truck dump to the breaker feed hoppers. Next, the raw coal is fed to either the thermal or the metallurgical breaker. The material is screened with a scalping screen with 50 mm openings. The oversize material enters the one of the rotary breakers, where the minus 50 mm material from the breaker mixes with the minus 50 mm material from the scalping screens. The plus 50 mm material rejected from the breaker is discharged to the breaker rejects rock pile. The post breaker raw coal is fed to one of the five raw coal silos. Each silo has its own belt feeder to feed either the thermal plant or the metallurgical plant.

Metallurgical Plant

Raw coal is fed to the metallurgical plant via the 4-way raw coal distributor. The raw coal is distributed to four deslime screens. Clarified water is added to the screens to aid the separation of coarse and fine raw coal.

Coarse Circuit

The oversize material generated from the deslime screens (plus 0.5 mm) is discharged into two heavy media sumps. Magnetite and water are added to the sumps to make up a prescribed specific gravity. The coal, magnetite and water slurry is pumped to four heavy media cyclones. In the heavy media cyclones, gravity separates the clean coal from refuse with the aid of the density of the slurry mixture. The clean coal is fed to the four clean coal drain and rinse screens to dewater the coal and recover the magnetite. Clarified water is used to wash the coal during this rinsing process. The clean coal screens discharge the coal to two coarse coal centrifuges for mechanical drying. Following the mechanical drying, the coal is fed to a fluidized bed dryer for the final stage of drying. The refuse from the cyclones reports to two refuse drain and rinse screens. The refuse screens have the same function as the clean coal screens. The refuse is then transported to a refuse bin and loaded onto a haul truck for transportation to the refuse dump.

Fines Circuit

The undersize material from the deslime screens (minus 0.5 mm) reports to the primary fine coal sump and is pumped to 16 primary water only cyclones. The underflow material is fed to six secondary water only cyclones. The underflow from the secondary water only cyclones is fed to the high frequency screen for dewatering and is discharged as refuse. The overflow of the secondary water only cyclones is used as a recycle stream and is fed back to the 4-way distributor. The overflow material from the primary water only cyclones is fed to the sieve bend sump and is then pumped to eight classifying cyclones. The underflow material from the classifying cyclones reports to the stack sizing screens where the ultra-fines are separated from the clean coal oversize. The oversize portion is then fed to four fine coal centrifuges. The undersize from the stack sizing screens is mixed with the overflow from the classifying cyclones and this product is fed to the flotation conditioning tank. Flotation collector (Nalco 9899) is added to the conditioning tank and then the slurry is pumped to the flotation feed distributor. Frother (Nalco 021) is added to the flotation feed as the slurry enters the separation cell. Air is added and the cells are agitated to produce bubbles. Hydrophobic coal, coated with collector, attaches to the air bubbles and floats to the surface to form froth that flows over the discharge lip of the cell and into a collection launder. This flotation concentrate is dewatered in the fine coal centrifuges along with the oversize from the stack sizing screens. The fine coal centrifuge cake is fed to a fluidized bed dryer for the final stage of drying. The tailings material from the flotation cells is fed to the refuse thickener. Anionic flocculant is added to the refuse thickener to accelerate the settling of the solids and the resulting underflow is fed to the belt presses, where the material is dewatered. The cake is then transported to a refuse bin and loaded onto a haul truck for transportation to the refuse dump with the coarse circuit refuse.

Thermal Dryer

The clean coal that is transported to the fluidized bed dryer flows over a rod deck. The dryer is natural gas fired. It consists of a large exhaust fan that draws hot air up through the rod deck, creating a fluidized bed of coal. The dried coal is transferred to one of three clean coal silos.

Thermal Plant

The thermal coal is discharged into a chute which can direct the flow to either one of two raw coal screens. One screen is set up to scalp coarse material (plus 6 mm) to feed the plant, with fines bypassing straight to product. The other screen is setup to feed all of the material for processing through the plant. Magnetite is added to the raw coal stream and it is all pumped to a single heavy media cyclone. The underflow from the heavy media cyclone reports to the refuse drain and rinse screen. The overflow from the heavy media cyclone reports to the clean coal drain and rinse screen and then to a coarse coal centrifuge for mechanical dewatering. The magnetite is recovered by the drain and rinse screens in the same manner as in the metallurgical plant.

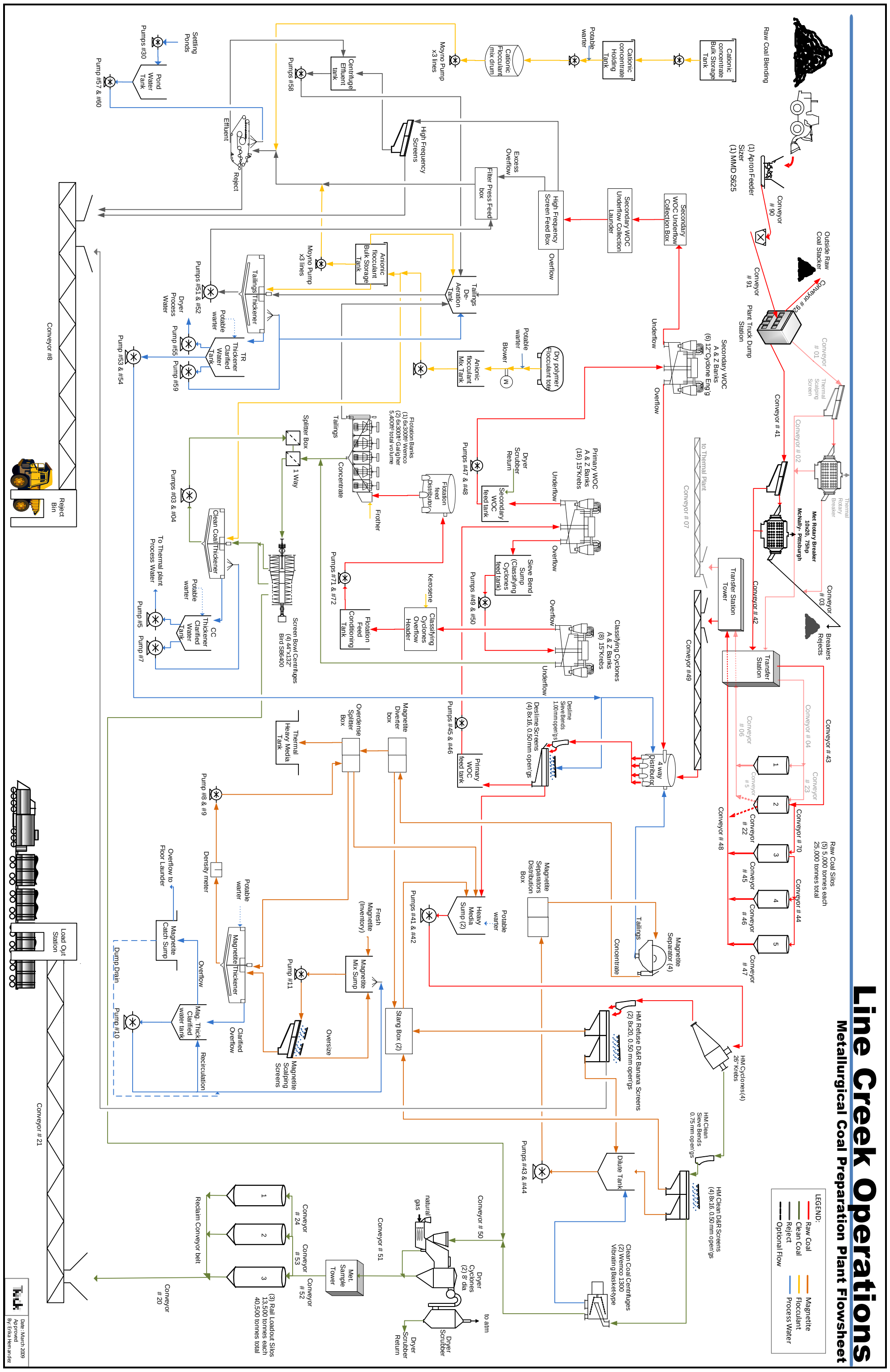

Figure 2-1 Process Flow Diagram for Line Creek Plant

Chapter 3.

Coal Business Unit Industry Analysis

Industry Definition

Industry Boundaries and Characteristics

Line Creek produces 3.2 Mmtcc of metallurgical coal and 0.3 Mmtcc of thermal coal annually. Metallurgical coal is required as a reducing agent in the coke and steel making process. The process of making coke from coal is a long standing process that has seen little technological advancements since the middle of the twentieth century. Once the coke is produced, it is shipped to the steel maker and is used as both structural support in the blast furnace and as a key ingredient in making steel. The development of the Electric Arc Furnace created a new alternative to produce steel. The operation of the Electric Arc Furnace requires scrap steel as a raw material input and has a large economic barrier to entry. When this is coupled with the stability and long term life of blast furnace, there is no current widespread substitute for the use of metallurgical coal in the coke and steel making process considering the current world growth.

Thermal coal is used in the process to generate electricity in coal fired power plants. There are many other technologies in current operation utilized to generate electricity, though the majority of electricity is still generated by using coal as the primary energy source in the United States and throughout the rest of the world.

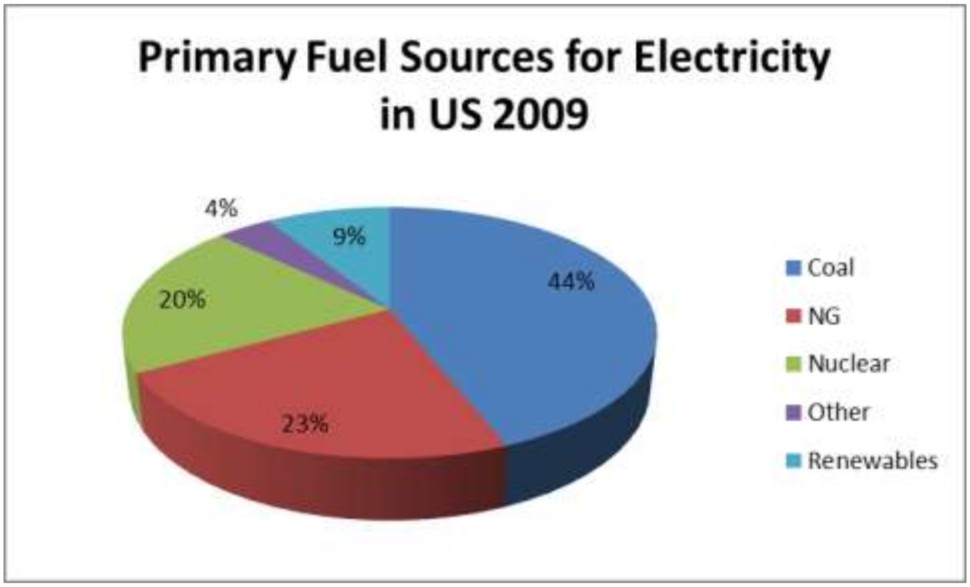

Figure 3-1 Primary Fuel Sources for Electricity in US 2009

Source:http://center.sustainability.duke.edu/resources/green-facts-consumers/what-largest-fuel-source-electricity-united-states

Both metallurgical and thermal coal demand will remain as these products are required in the coke and steel making process as well as the electricity generation process. Line Creek sells its coal to a diverse group of customers located worldwide, who utilize our product for the same purpose. However, our customers do have the option to purchase metallurgical and thermal coals from other manufacturers.

The geographical region of competitors within Canada is dominated by Teck Coal. The majority of the coal deposits in Canada are located in Saskatchewan, Alberta and British Columbia. Of all the operating coal mines in Canada, Teck Coal operates six and produces 25 to 27 Mmtcc annually. Teck Coal's competition lies largely with BHP and the coal mines operating in Australia.

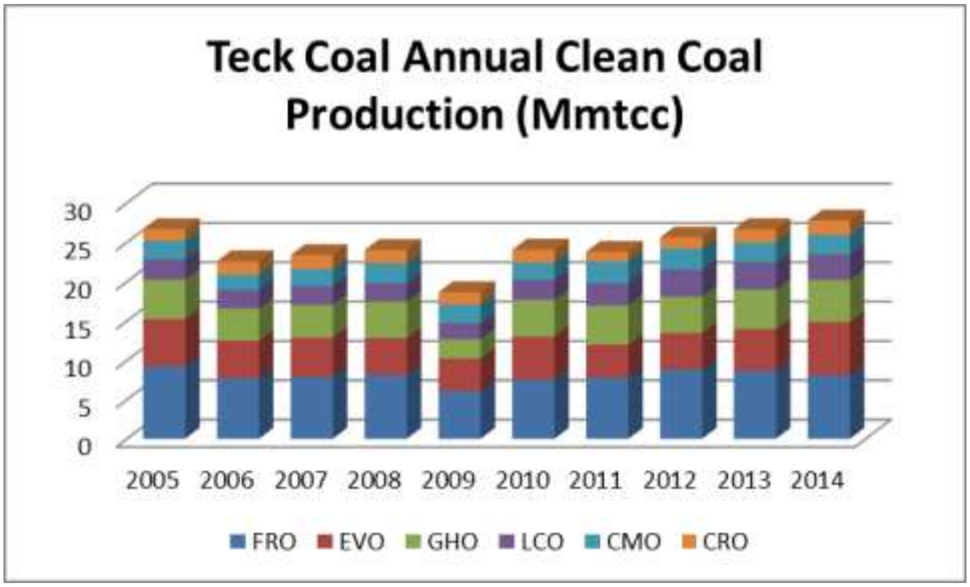

Figure 3-2 Teck Annual Clean Coal Production

Source: Teck Coal Mine Comparison Report 2005-2014

Supply Chain

The supply chain is quite simple and linear. The raw coal is supplied to the Processing facility from the Mine Operations group. The major activities required are drilling, blasting, loading and hauling. Any other inputs to the process at this point include methods and materials to maintain the heavy equipment to ensure a steady state production output of raw coal. At Line Creek, the raw coal is delivered to the Processing facility via an 11 km cable belt. Once the raw coal has arrived, it is stored in the raw coal silos prior to being fed to the Processing wash plant. The wash plant generates a saleable product and facilitates the loading of the clean coal onto unit trains operated by Canadian Pacific Railways. The unit trains deliver the clean coal to one of four port facilities or several direct customers. The majority of the clean coal is delivered to Westshore terminals in Vancouver. From the terminal, the clean coal is loaded onto cape or panamax sized vessels and delivered to our customers worldwide.

Industry Dynamics

Porter’s (Augmented) Five Forces

The overall analysis of Porter’s (Augmented) Five Forces from the perspective of Line Creek and Teck Coal generates an industry that is not attractive for new entrants into the industry.

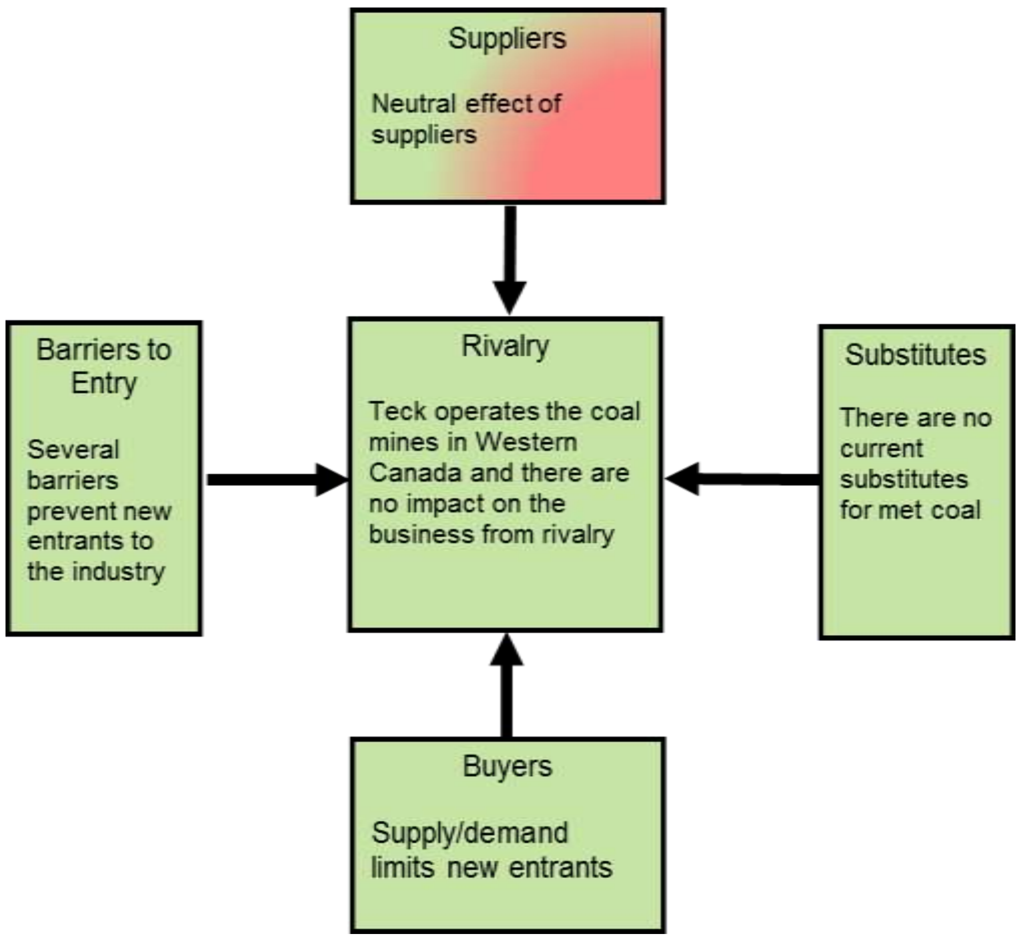

Figure 3-3 Porter's (Augmented) Five Forces Analysis

Source: Porter, Michael E., The Five Competitive Forces That Shape Strategy

Degree of Rivalry

Given that all six of the industry competitors in the Western Canadian metallurgical coal market operate for Teck Coal, there is no impactful rivalry. The six coal mines operate with one collective customer base and fulfill contract orders in a united manner. The current strategy is to grow the market share of the Teck Coal Business unit as a whole, not cannibalize the internal participants. Outside of the Elk Valley in the world seaborne metallurgical coal market, there is significant competition. The current market war is a clear example of this rivalry. The strategy for BHP is to continue over production of metallurgical coal compared to the demand of this product. The result of this strategy is shrinking margins. This effect coupled with the US dollar exchange rate adds great pressure to Teck to be efficient and cost effective in all its Coal Business Unit Operations.

Barriers to Entry

There are several barriers to enter into the coal market in Western Canada. There is a barrier related to the economy of scale. Firstly, the geological nature of the metallurgical coal industry dictates that the source of the commodity is limited. In addition, Teck owns the mining rights for the area in the Elk Valley, which is the physical location of the input for the final product. Secondly, it would require significant capital monies to begin a greenfield operation. This in effect has eliminated the ability of small or medium sized mining companies to directly compete for market share in the industry, and limited the large established mining companies. Thirdly, there is a greater requirement for permitting and water qualities related to the mining function. This change has been fully seen when Line Creek went through the process of permitting a new mining area, Phase II.

There is a barrier to accessing the supply chain flow of the commodity. The infrastructure to transport the clean metallurgical coal is limited. There is one main line that services the Elk Valley, and it currently transports 24 to 25 Mmtcc to the west coast of Canada annually. Canadian Pacific Railway operates as a monopoly service provider for Teck Coal and this would also be the case for any new entrant to the industry. Again, this acts as an increased cost versus other mining options worldwide for a new entrant.

There is a barrier to entry related to government policy. New Provincial and Federal regulations have been implemented and this has created a large first hurdle for an aspiring corporation to set up an operation in Western Canada. A new and more environmentally protective process has been established in order to ensure mining in a socially responsible manner. This has resulted in a long application process involving all the associated stakeholders and their commitments to the mining process. Dedicated funding for reclamation is a significant change with the new expectations and will deter any new entrants into the industry. With respect to the water quality needs in the permit application, this would consider constituents of concern, biodiversity, First Nations, deleterious substances, fish habitat and conservation. At Line Creek, the process was five years from start to finish and provided great detail in the aforementioned areas in order to begin mining in Phase II. Overall, there is a significant barrier to entry for new participants into the metallurgical coal industry in Western Canada

Substitutes

There are no substitutes for metallurgical coal. The vast majority of iron production is through blast furnace technology. Metallurgical coal is required as a reducing agent in the coke and blast furnace steel making process. Iron making is a well-established process that has been evaluated for alternatives for quite some time. There are several alternatives, though none have currently usurped blast furnace technology as the primary method to produce iron. Even in times of high coal prices, these alternative technologies have yet to be fully developed or implemented.

Buyer

There are many buyers for coal worldwide. Metallurgical coal prices are set on a quarterly basis and these contract prices are set based on the baseline spot prices for the major brands of metallurgical coal. Since the buyers of metallurgical coal have limited choices to purchase, and the producers also have limited choices, a situational parasitic relationship exists. This is dependent on the current economic conditions of supply and demand. New entrants into the industry would increase the supply side of the equation and the price would drop accordingly. This acts as another positive facet for Line Creek and Teck Coal.

Supplier

The labour market in the Elk Valley is relatively stable. There have been very few work disruptions in the history of the operations. The area attracts individuals who seek a stable and consistent environment for work and family. This would act to make it attractive for new entrants into the industry.

A considerable input to the mining process is the heavy equipment utilized to generate the raw coal for processing betterment. There are several choices for equipment, thought the majority of all trucks are supplied by one of two manufacturers. The supplier has the option to maintain its revenue by distributing its product to numerous other mining companies outside of the metallurgical coal mining industry. This would act to make it unattractive for new entrants into the industry.

This force is less important than other forces in the analysis, though overall it would be relatively neutral in comparison.

Gap Analysis

The objective of any publicly traded company is to create shareholder value. The opportunity that presents itself for Line Creek and Teck Coal is to increase the annual output of saleable metallurgical clean coal. And as a result decrease the unit costs for the Line Creek Operation and the shareholder value will be improved by an increase in the unit cost margin for Line Creek and Teck Coal. The decrease of the unit operating cost at Line Creek is what is directly in the control of the site employees, and is the mechanism by which shareholder value is increased. Line Creek currently operates three separate product streams that run in parallel. Two of which generally produce metallurgical coal. The third footprint is solely dedicated to produce thermal coal. By adding to the existing capacity of the two metallurgical streams, an increase in metallurgical coal production will be realized with little increase to the total operating costs. The total production which Teck Coal has achieved is currently at a ten year high and has consistently increased over the last three years up to 27.8 Mmtcc in 2014.

For the purposes of analyzing the opportunity by the way of increasing the Line Creek production, the subsequent totals for Teck Coal production achievable would increase. For the purpose of this analysis, the assumption is that the Line Creek Mine Operations department can supply the addition coal required, an increase matching the increase of the clean coal output of 21% for the 4 Mmtcc scenario and 51% for the 5 Mmtcc scenario.

Table 3-1 Teck Coal Annual Production

Annual Production - MTCC		
	LCO	Total
2012	3,415,797	25,584,394
2013	3,426,156	26,636,935
2014	3,271,073	27,755,445

Source: Teck Coal Mine Comparison Report 2012-2014

Table 3-2 Teck Coal Adjusted Annual Production with Line Creek at 4 Mmtcc

Annual Production - MTCC (4Mmtcc)		
	LCO	Total
2012	4,000,000	26,168,597
2013	4,000,000	27,210,779
2014	4,000,000	28,484,372

Source: Teck Coal Mine Comparison Report 2012-2014

Table 3-3 Teck Coal Adjusted Annual Production with Line Creek at 5 Mmtcc

Annual Production - MTCC (5Mmtcc)		
	LCO	Total
2012	5,000,000	27,168,597
2013	5,000,000	28,210,779
2014	5,000,000	29,484,372

Source: Teck Coal Mine Comparison Report 2012-2014

As expected, the productivities of metric tonnes of clean coal per work shift increased in both scenarios and are more in line with the other coal processing facilities within Teck Coal. As a result of producing additional saleable coal, the generation of additional refuse material is inevitable. A need is now created to transport the additional material to the refuse dump. This would result in the need for two additional persons to complete this task. The added work shift hours are reflected in the adjusted productivities for Line Creek in both adjusted scenarios.

Table 3-4 Teck Coal Process Plant Productivities

Productivity - MTCC/WS						
	FRO	EVO	GHO	LCO	CMO	CRO
2012	30	18	31	27	34	12
2013	30	21	34	28	33	16
2014	27	27	35	24	34	20

Source: Teck Coal Mine Comparison Report 2012-2014

Table 3-5 Teck Coal Adjusted Process Plant Productivities with Line Creek at 4 Mmtcc

Productivity - MTCC/WS (4Mmtcc)						
	FRO	EVO	GHO	LCO	CMO	CRO
2012	30	18	31	31	34	12
2013	30	21	34	32	33	16
2014	27	27	35	29	34	20

Source: Teck Coal Mine Comparison Report 2012-2014

Table 3-6 Teck Coal Adjusted Process Plant Productivities with Line Creek at 5 Mmtcc

Productivity - MTCC/WS (5Mmtcc)						
	FRO	EVO	GHO	LCO	CMO	CRO
2012	30	18	31	38	34	12
2013	30	21	34	39	33	16
2014	27	27	35	35	34	20

Source: Teck Coal Mine Comparison Report 2012-2014

The percentage of total dollars spending of Line Creek in relation to Teck Coal total dollars spending will increase. For the purposes of the analysis, a value of 20% fixed costs was used for the Processing department and a value of 60% fixed costs was used for the rest of Line Creek Operations. The remaining portion of the total costs are variable and will increase accordingly as the production output increases in each case.

Table 3-7 Line Creek Percent of Total Spending for Teck Coal

% of Total Spending	
	LCO
2012	8.9%
2013	14.1%
2014	12.2%

Source: Teck Coal Mine Comparison Report 2012-2014

Table 3-8 Line Creek Adjusted Percent of Total Spending with Line Creek at 4 Mmtcc for Teck Coal

% of Total Spending (4Mmtcc)	
	LCO
2012	9.7%
2013	15.1%
2014	13.4%

Source: Teck Coal Mine Comparison Report 2012-2014

Table 3-9 Line Creek Adjusted Percent of Total Spending with Line Creek at 5 Mmtcc for Teck Coal

% of Total Spending (5Mmtcc)	
	LCO
2012	10.9%
2013	16.8%
2014	14.9%

Source: Teck Coal Mine Comparison Report 2012-2014

The percentage of total production for Line Creek versus the Teck Coal total production will increase and be more in line with the share of other midsized Teck Coal mines in both scenarios.

Table 3-10 Teck Coal Percent of Total Production

% of Total Production						
	FRO	EVO	GHO	LCO	CMO	CRO
2012	34.3%	18.2%	18.2%	13.4%	10.5%	5.5%
2013	32.5%	19.7%	19.1%	12.9%	9.6%	6.3%
2014	29.1%	24.4%	19.2%	11.8%	9.0%	6.5%

Source: Teck Coal Mine Comparison Report 2012-2014

Table 3-11 Teck Coal Adjusted Percent of Total Production with Line Creek at 4 Mmtcc

% of Total Production (4Mmtcc)						
	FRO	EVO	GHO	LCO	CMO	CRO
2012	33.5%	17.8%	17.8%	15.3%	10.2%	5.4%
2013	31.8%	19.3%	18.6%	14.7%	9.4%	6.1%
2014	28.4%	23.8%	18.7%	14.0%	8.8%	6.4%

Source: Teck Coal Mine Comparison Report 2012-2014

Table 3-12 Teck Coal Adjusted Percent of Total Production with Line Creek at 5 Mmtcc

% of Total Production (5Mmtcc)						
	FRO	EVO	GHO	LCO	CMO	CRO
2012	32.3%	17.1%	17.2%	18.4%	9.9%	5.2%
2013	30.7%	18.6%	18.0%	17.7%	9.1%	5.9%
2014	27.4%	23.0%	18.0%	17.0%	8.5%	6.1%

Source: Teck Coal Mine Comparison Report 2012-2014

A ratio of the percent of total spending and the percent of total production shows that following an increase to 4 Mmtcc, Line Creek is spending less than would be expected compared to the production output. This final ratio is indicative of a relative decrease in operating costs and the ability to successfully increase the unit cost margin compared to Teck Coal operations with similar production outputs. This metric highlights the opportunity for Line Creek to produce more clean coal at a spending efficiency that is comparable to other Teck Coal mines that have been at this annual saleable clean coal output for over 10 years. Furthermore, when the adjusted production for Line Creek is increased up to 5 Mmtcc, only CMO betters Line Creek in the spending share and production share ratio.

Table 3-13 Teck Coal Ratio of Percent of Total Spending and Percent of Total Production

Cost Ratio of % of Total Spending and Production

	FRO	EVO	GHO	LCO	CMO	CRO
2012	0.90	1.22	0.95	0.67	0.82	2.20
2013	0.94	1.08	0.85	1.10	0.71	1.76
2014	1.14	0.92	0.91	1.03	0.61	1.41

Source: Teck Coal Mine Comparison Report 2012-2014

Table 3-14 Teck Coal Adjusted Ratio of Percent of Total Spending and Percent of Total Production with Line Creek at 4 Mmtcc

Cost Ratio of % of Total Spending and Production (4Mmtcc)

	FRO	EVO	GHO	LCO	CMO	CRO
2012	0.91	1.24	0.97	0.63	0.84	2.23
2013	0.95	1.09	0.86	1.03	0.72	1.77
2014	1.15	0.93	0.93	0.95	0.66	1.42

Source: Teck Coal Mine Comparison Report 2012-2014

Table 3-15 Teck Coal Adjusted Ratio of Percent of Total Spending and Percent of Total Production with Line Creek at 5 Mmtcc

Cost Ratio of % of Total Spending and Production (5Mmtcc)						
	FRO	**EVO**	**GHO**	**LCO**	**CMO**	**CRO**
2012	0.93	1.27	0.99	0.59	0.86	2.29
2013	0.96	1.11	0.87	0.95	0.73	1.80
2014	1.17	0.95	0.94	0.88	0.63	1.45

Source: Teck Coal Mine Comparison Report 2012-2014

Line Creek can realize an increase in annual production and a decrease in unit costs by increasing the capacity of the metallurgical plant. In order for this transition to be successful, there are several conditions that must be met.

By increasing the production of Line Creek, no other Teck Coal operation may suffer a loss of production. Losses of production typically result for two reasons that are affected by the other operations: either the additional metallurgical coal production cannot be sold to a customer, or the additional metallurgical coal production cannot be transported to the port facilities in a timely manner, which would effectively decrease the total annual production. Not only does the total amount need to be delivered to the port, but it also needs to be transported in a steady state flow in order to not disrupt the Teck Coal production schedules.

Additional capital costs would be required for both the Mine Operations requirements to generate raw coal at a greater rate and for the Processing facility to add capacity to produce metallurgical coal using the existing infrastructure. These details are explored in Chapter 4, Bottleneck Analysis.

Lastly and paramount to the success of the opportunity, by increasing the production at Line Creek, there must be no acute or cumulative negative effects to the environment or the communities of interest. The details of these items are outlined in Chapter 6, Other Impacts on Line Creek Capacity Increases. Teck Coal operates with core values that include the aforementioned topics.

Chapter 4.

Bottleneck Analysis

Following a high mark in plant feed rate from 2012, the current and forecasted plant feed rate is depressed in comparison. This is as a result of the increased need to run thermal coal through our metallurgical processing plant. This need exists in order to continue the steady state delivery of raw coal to the Processing Plant, originated by the existing Mine Operations limitations in production. The short term focus will be on optimizing our existing process to maximize the coal recovery. The long term opportunity will be to incorporate further improvements to the current coarse circuit, fine coal circuit, dryer circuit and the cable belt.

Two natural bottlenecks surface from the equipment capacity calculations. The two bottlenecks are an annual production output of 4 Mmtcc and 5 Mmtcc.

4.0 Million mtcc Bottleneck

A major limitation to Line Creek is the 11 km cable belt. The cable belt is the life line between the Mine Operations and the Processing Plant. The cable belt limits the amount of saleable clean coal Line Creek can produce annually. Table 4.1 below illustrates the capacity limitation of the cable belt and yields the first scenario to be analyzed of an annual saleable clean coal production from Line Creek of 4 Mmtcc. The calculation below assumes that the production ratio of standard coal (831) and eagle coal (835) is 1:1 for future operating years. The annual thermal coal production is also constant at 300,000 mtcc. Although the thermal production does not affect the metallurgical plant, it does require cable belt operating time to maintain a thermal plant feed inventory. The availability of the cable belt, the tonnes per hour, operating days, yield by product and the breaker rejects value represents a historical level of sustainable achievement for all metrics.

Table 4-1 Base Case Cable Belt Capacity

Base Case Cable Belt Capacity			
Product	**831**	**835**	**Total**
TPH	925	925	
Availability	90%	90%	
Op Days	165	165	
Breaker Reject	6%	6%	
Yield	71.8%	76.7%	
Total Raw Tonnes	2,711,500	2,711,500	5,423,000
833 Raw Tonnes			428,500
Met Raw Tonnes			4,994,500
833 Clean Tonnes			300,000
Met Clean Tonnes	1,793,000	1,915,500	3,708,500
Total Clean Tonnes			4,008,500

In order to overcome the current 3.5 Mmtcc bottleneck in the Line Creek Processing Plant, a 50% increase in capacity is required in the coarse circuit only. This can be done by upgrading the deslime screens, adding two heavy media cyclones and upgrading the associated heavy media pumps, sumps and piping. The new clean tonnes per hour capacity and total capacity are illustrated below in Table 4-2. As shown the new capacity exceeds the current cable belt capacity. Following the upgrade to the coarse circuit, the new Processing bottleneck is the cable belt. In addition to the newly created cable belt bottleneck, the pre-existing capacity issues of the fines circuit and the dryer would begin to be operational issues when 4 Mmtcc annual production is exceeded. The control of the total moisture for the saleable product is controllable in the 8.0-8.5% range when the clean coal tonnes per hour rate is at 550 ctph. This matches the calculated scenario below. This calculation assumes that the fine circuit capacity remains unchanged. Given the increase in the total feed rate and the assumption that the coarse fraction of both standard (831) and eagle (835) coals remains constant throughout the mine life, there will also be additional fine coal fed to the plant. The ability to process the fine coal will hinge on the current flexibility in the process to either keep the fine coal as product or transport the incremental fine coal to the refuse dump.

Table 4-2 Plant 4 Mmtcc Capacity

Plant 4 Mmtcc Capacity			
Product	**831**	**835**	**Total**
Coarse Amount	75%	70%	
Current RTPH	662	528	595
Availability	92%	92%	
Op Days	165	165	330
Current CTPH	437	373	405
Yield	71.8%	76.7%	
New RTPH	910	713	812
New CTPH	601	503	552
833 Clean Tonnes			300,000
Met Clean Tonnes	2,381,000	1,991,500	4,372,500
Total Clean Tonnes			4,672,500

The 4 Mmtcc ceiling dictated by the existing cable belt infrastructure is one of several limitations that must be overcome in order to produce more saleable clean coal at Line Creek. For the purposes of this analysis, two fundamental boundary conditions will be adhered to. The construction of additional building infrastructures will be avoided as there currently exists ample floor space for equipment capacity increases. Secondly, Line Creek possesses the most length of conveyors in the Teck Coal Business Unit. The conveyor system is unique and complex, and already requires many hours to maintain in good operating condition. The premise of decreasing the unit costs of the operation would not be maintained if an additional conveyor maintenance burden was added.

5.0 Million mtcc Bottleneck

Given the boundary conditions for the expansion, no additional building infrastructure, the result is a second bottleneck capacity ceiling of 5 Mmtcc. The calculation for the capacity increase to 5 Mmtcc is based on a 50% capacity increase in the coarse and fine coal equipment. This can be done while maintaining the current building and conveyor infrastructure at Line Creek. Table 4-3 displays the details under similar assumptions as the cable belt capacity calculation. One notable difference is the historic availability of the metallurgical processing plant is higher than that of the cable belt. Also, the coarse to fine percentage varies by metallurgical product. This value is 75% coarse for standard coals and 70% coarse for eagle coals.

Table 4-3 Plant 5 Mmtcc Capacity

Plant 5 Mmtcc Capacity			
Product	**831**	**835**	**Total**
Coarse Amount	75%	70%	
Current RTPH	662	528	595
Availability	92%	92%	
Op Days	165	165	330
Current CTPH	437	373	405
Yield	71.8%	76.7%	
New RTPH	993	792	893
New CTPH	656	559	607
833 Clean Tonnes			300,000
Met Clean Tonnes	2,597,500	2,213,000	4,810,500
Total Clean Tonnes			5,110,500

In order to achieve the 5 Mmtcc scenario, both the fine coal circuit and the coarse coal circuit capacities must be increased by 50%. In addition, the existing drying circuit will not successfully control the total moisture of the saleable product to the level in the 4 Mmtcc scenario. Lastly, the system to deliver raw coal to the Processing Plant must be upgraded.

The method by which to increase the fine coal circuit capacity by 50% is by adding eight WOC's, four FCC's and all four conveyors on the clean coal side. The clean coal conveyors are able to handle the average capacity of 550 ctph in the 4 Mmtcc scenario, but not the average capacity of 600 ctph in the 5 Mmtcc scenario. The four clean coal conveyors can be sped up by the 10% in order to accommodate the additional load. This can be accomplished by an increase in the motor size for each conveyor. In addition, work would be considered to increase the flowability to the discharge and feed chutes in order to effectively transfer the coal from conveyor to conveyor with minimum spillage. The existing flotation cells have the capacity to handle the increase in the fine coal circuit. The froth crowders would be removed to maintain the flotation cell retention time within the acceptable operating range for efficiency. The increase will also cause a larger amount of material to flow through other unit operations. The refuse thickener and clean coal thickener will experience changes in the daily operating conditions. These changes in the thickener tanks can be managed with the modification of settling agents like anionic and cationic flocculants. There is a need to increase the pumps that output solids from both settling thickeners. The solids generated will increase on the clean and refuse streams. The refuse solids can be handled by the existing three belt press filters, as currently, one belt press filter is an on-line spare. The belt press filter feed tank will need to be upsized to handle the additional load. The increase in the fine clean coal will require upgrades to the drying circuit.

In order to continue to produce saleable clean coal to a total moisture of 8.0-8.5%, a drying circuit upgrade all four screen bowl centrifuges is required. The existing screen bowl centrifuges employs technology that is 30 years old. New, larger and more efficient screen bowl centrifuges can be obtained that would allow the 5 Mmtcc capacity plant to maintain the 8.0-8.5% total moisture. The distribution of material to the screen bowl centrifuges would also be modified to allow the increase in flow. The last upgrade required is the method by which to deliver the raw coal to the plant itself.

An increase of 30% is required to the capacity of the raw coal delivery system to accommodate the 5 Mmtcc scenario, as displayed in Table 4-4. This can be accomplished in several ways. For the purpose of this analysis, utilizing heavy equipment will not be considered as it would introduce a significant concern. A safety concern of heavy equipment and light vehicle interactions is avoided whenever possible in Teck's mining environments, as the risk is too great compared to the potential benefits in productivity.

Table 4-4 Cable Belt 5 Mmtcc Capacity Case

Base Case Cable Belt Capacity			
Product	**831**	**835**	**Total**
TPH	1200	1200	
Availability	90%	90%	
Op Days	165	165	
Breaker Reject	6%	6%	
Yield	71.8%	76.7%	
Total Raw Tonnes	3,517,500	3,517,500	7,035,000
833 Raw Tonnes			428,500
Met Raw Tonnes			6,606,500
833 Clean Tonnes			300,000
Met Clean Tonnes	2,372,000	2,533,500	4,905,500
Total Clean Tonnes			5,205,500

The first option to increase the cable belt capacity would be to upgrade the motor and drive system and the speed up the conveyor by the required 30%. Concerns in this option arise surrounding the increase in environmental concerns. The increase speed of the cable belt will increase the raw coal that is spilled from the carrying surface. The cable belt operates in such a manner that the cable that the belt rides on is not fixed to the belt, rather it supports the belt as the apparatus travels over fixed line stands with moving pulleys. The height of the cable belt pulleys are designed to produce a level and even movement of the belt, but inevitably, the height varies, causing the belt to bounce up and down, mirroring the imperfection in the pulley height from line stand to line stand. This bouncing allows coal to spill off the belt and onto the ground. The coal deposited onto the ground creates a risk to environmental non-compliance with regards to coal washing into the adjacent creek. For this reason, the option to speed up the cable belt is not attractive.

Figure 4-1 Line Creek Operations Cable Belt

A company called Railveyor has a technology that can be supplied for the same operating costs as the current cable belt and can meet the raw coal supply needs of the Processing Facility. The Railveyor technology is a process of small container cars that travel on a fixed rail system. The new technology has less impact on the environment, as the spillage of coal is less. The system is modular and scalable. This could provide Line Creek with a flexible system to deliver raw coal to the Processing Facility. The drawback of this system is that it is new to Teck and our experience and skillset is not strong with this type of material moving technology. Also, there will be different equipment required to load and off load the container cars. Lastly, there are issues that could arise with weather and the amount of snow that the Elk Valley receives. Removing the snow causes another new issue that needs to be maintained on a shift by shift basis.

Regardless of the type of technology employed, the ability to increase the annual production to 5 Mmtcc is not limited by a system to deliver raw coal to the Processing Facility. The primary factor in the method of this decision revolves around the additional impact to the environment and Line Creek, which travels adjacent to the current cable belt.

Chapter 5.

Economic Analysis of Capacity Options

The assumptions used for future financial predictions were taken from the Teck Coal appropriation requisition assumptions for Q1 2015. These assumptions forecast coal selling price excluding ocean freight, cash costs of production (including capital) and transportation costs excluding ocean freight. Using these forecasts for 2015 onward, a base case NPV was calculated. With a 10 year useful life and an 8% interest rate, the NPV calculated with the Q1 2015 predicted growth in selling price and without making any Processing Plant capacity increases was $1,034M.

Considering the current state of the coal market, a second base case was calculated. The second case predicts a static selling price for coal as predicted in the Q1 2015 Teck Coal appropriation requisition assumptions. Again, a 10 year useful life and an interest rate of 8% were utilized. The resulting NPV without making any Processing Plant capacity increases was $261M.

These two base cases serve as the comparison by which the 4 Mmtcc scenario and the 5 Mmtcc scenario will be evaluated. The details of the calculations are located in the Appendix.

4.0 Million mtcc Scenario

The additional capital dollars required in order to achieve an annual production of 4 Mmtcc saleable clean coal is listed below in table 5-1. All of the upgrades needed in this scenario are in the Processing Plant and the costs would be incurred in 2016.

Table 5-1 Capital Dollars for 4 Mmtcc Capacity ($000's)

Capital Dollars for 4 Mmtcc Capacity ($000's)			
	Parts	Install	Total
Deslime Screen (4)	800	800	1,600
Heavy Media Cyclone (2)	150	450	600
HMC pump (2)	100	200	300
HMC sump (2)	600	600	1,200
HMC piping	300	500	800
Total	1,950	2,550	4,500

The NPV calculation for the 4 Mmtcc scenario when using the increasing predicted coal selling price is $1,285M. This is an increase from the comparable 3.5 Mmtcc base case of $251M or 24% of the base case NPV. The IRR is 12.6% with a BCR of 55.8.

When a static coal sale price is assumed over the next 10 years, the NPV for the 4 Mmtcc scenario becomes $402M compared to the parallel 3.5 Mmtcc case of $261M. The difference in this case is $141M or a 54% increase from the base case NPV. For the static coal sale price, the IRR is 20.7% with a BCR of 31.4.

Even during a period of volatile sales prices, the benefit of increasing the output of the Line Creek Processing facility is evident based on the Q1 2015 Teck Coal appropriation requisition assumptions.

5.0 Million mtcc Scenario

The additional capital dollars required in the Processing Plant in order to achieve an annual production of 5 Mmtcc saleable clean coal is listed below in table 5-2. All of the upgrades listed would be incurred in 2017. In order to achieve the objective of 5 Mmtcc, the upgrades outlined in the 4 Mmtcc scenario must also be accomplished as previously outlined.

Table 5-2 Capital Dollars for 5 Mmtcc Capacity Plant ($000's)

Capital Dollars for 5 Mmtcc Capacity Plant ($000's)			
	Parts	**Install**	**Total**
Water Only Cyclone (8)	400	400	800
WOC discharge tub (2)	400	400	800
WOC pump (2)	100	500	600
WOC sump (1)	200	200	400
WOC piping	300	300	600
Fines Classifying Cyclone (4)	200	200	400
FCC discharge tub (2)	150	150	300
FCC pump (2)	200	200	400
FCC sump (1)	200	200	400
FCC piping	300	300	600
50 c/v motor	50	25	75
51 c/v motor	50	25	75
52 c/v motor	100	50	150
52 c/v motor cable	100	100	200
52 c/v discharge chute	100	100	200
53 c/v motor	50	25	75
Screen Bowl Centrifuge (4)	3,000	725	3,725
SBC Distributor (1)	100	300	400
CC Thickener U/F pump (2)	100	200	300
Ref Thickener U/F pump (2)	100	200	300
Belt Press Feed Tank (1)	100	100	200
Total	6,300	4,700	11,000

In addition to the significant Processing Plant upgrades, there is a need for additional mining equipment to supply the raw coal required to produce 5 Mmtcc. The mining equipment required would incur significant capital dollars in 2017 as listed in Table 5-3. For the purposes of this analysis, it is assumed that the Mine Operations is able to meet the requirements of the Processing Facility. There are too many factors here to list or discuss in a meaningful detailed manner.

Table 5-3 Capital Dollars for 5 Mmtcc Capacity Mine ($000's)

Capital Dollars for 5 Mmtcc Capacity Mine ($000's)	
4 shovel	4,000
4 shovel replacement	28,000
Haul Truck (9)	49,500
Shop Upgrade	7,000
Drill	6,000
Total	94,500

The NPV calculation for the 5 Mmtcc scenario when using the increasing predicted coal selling price is $1,591M. This is an increase from the comparable 3.5 Mmtcc base case of $557M or 54% of the base case NPV. The IRR is 16.9% with a BCR of 5.1.

When a static coal sale price is assumed over the next 10 years, the NPV for the 5 Mmtcc scenario becomes $498M compared to the parallel 3.5 Mmtcc case of $261M. The difference in this case is $237M or a 91% increase from the base case NPV. For the static coal sale price, the IRR is 23.7% with a BCR of 2.2. A summary of the calculated values are displayed below in table 5-4.

Table 5-4 Economic Analysis Summary

Economic Analysis Summary ($000's)			
	NPV	**IRR**	**BCR**
3.5 Mmtcc with price growth	1,034		
4.0 Mmtcc with price growth	1,285	12.6%	55.8
5.0 Mmtcc with price growth	1,591	16.9%	5.1
3.5 Mmtcc static price	261		
4.0 Mmtcc static price	402	20.7%	31.4
5.0 Mmtcc static price	498	23.7%	2.2

The 4 Mmtcc scenario possesses a strong BCR in cases of a coal price growth market and a static coal price market. This speaks to the low economic risk associated with this scenario. Conversely, the 5 Mmtcc scenario is not nearly as attractive when you consider the possibility of static coal sale prices over the next ten years. An overall capital investment of $110M that yields a ten year NPV value increase from the 3.5 Mmtcc base case of $237M is not nearly as lucrative compared to a NPV value increase of $141M versus a $4.5M investment for the 4 Mmtcc scenario.

Chapter 6.

Other Impacts on Line Creek Capacity Increases

As stated in the 2014 Line Creek Life of Mine Plan, the current mine life has operations until 2036. By advancing the saleable clean coal output to 4 Mmtcc, an annual rate increase of 14% will result in shortening the current end of mine life to 2033. However, by increasing the annual production to 5 Mmtcc, the 43% increase would shorten the mine life to 2025. Consider in the latter scenario a constant mining strip ratio and a constant Processing Plant yield, the mining waste generated and the plant refuse generated would also increase by 43% from 2017 until 2025. This additional rate of waste and refuse deposition would create an additional burden to manage correctly to ensure proper construction and water management. Also, the increase rate of waste deposition has a potential to create a risk of geotechnical issues. Lastly, the increase rate of production would cause issues in maintaining efficient shovel headings. Line Creek possesses thin seams and adding a shovel to the production schedule would make the planning and mining process more complex and as a result more volatile and subject to unreliability. This result does not mesh with the current objective of Line Creek to be leaders in operational excellence. The 5 Mmtcc scenario contains far more uncertainty in the aforementioned aspects as does the 4 Mmtcc scenario.

The impact of more saleable clean coal production annually also has the potential to affect Line Creek's environmental reputation. Line Creek Operations has worked tirelessly in order to create a working relationship with NGO's, government agencies and communities of interest. A clear example of this process is the recent Phase II application. Consideration must be taken in order to assess the impact of either the 4 Mmtcc or the 5 Mmtcc increase in this regard. The increase in mining activities may impact the release of selenium, calcium deposition, nitrates or other undesired constituents in the Line Creek tributary. Either an increase in the aqueous concentration or an increase in the volumetric flow rate would require a clear management action plan to mitigate or eliminate the hazard. Closer to home, the location of Grave Lake is within 2 km of the Line Creek Processing Plant. An increase in the generation of refuse would accelerate the Processing Plant Refuse Dump. There is a permitted boundary limit and a new location for dumping this material would be required to be sourced much sooner with the 5 Mmtcc scenario.

Can the Teck Marketing group sell the additional coal? This is a big unknown. The current market is experiencing an over-supply state with dropping prices. This is not an attractive environment for large additions to Teck's coal sales volume portfolio. The shrinking GDP growth rate for China coupled with the move to use more domestic coal and the newly developed tariff on coal imports complicates the situation to sell coal in China. Australian coal producers continue to over-supply the market, and since their market share is significantly greater than Teck's, the power to control the selling price lies firmly with the Australian producers. The over-supply would squeeze Teck and may force a choice between sales volume and realized coal sale price. With the current company objectives and projects, cash flow is an important factor to consider. This makes the 5 Mmtcc scenario much less attractive than the 4 Mmtcc scenario.

Finally, can the additional saleable clean coal be transported to the vessel loading facilities? Teck relies on Canadian Pacific Railways to provide a service to transport our coal. Forecasting of the monthly production by mine is utilized in order to determine the number of unit trains required on a daily basis to maintain the steady state flow of saleable clean coal from the Elk Valley. Currently, Line Creek receives 220 unit trains per year or 4.25 trains per week. By increasing the production rate to 4 Mmtcc, Line Creek would require 31 additional trains each year to move the incremental saleable clean coal, or 4.83 trains per week. By increasing the production rate to 5 Mmtcc, Line Creek would require 63 trains over the 4 Mmtcc scenario, or 6.04 trains per week. Again, similar to the ability to sell the coal, the mine life length impact, the potential environmental, social and community impacts, the 5 Mmtcc scenario contains many more uncertainties and risks than the 4 Mmtcc scenario.

Chapter 7.

Recommendations

The option to increase the annual production to 5 Mmtcc is not recommended to be implemented. In comparison to the 4 Mmtcc option, the lower BCR for the 5 Mmtcc is significant. Also, the current metallurgical coal price environment has squeezed the margin realized for Teck Coal. This has produced the effect of a close focus on quarterly cash flow for the Coal Business Unit. The request to spend an excess of $100M in capital money in a two year period at Line Creek for a project that only results in an increase of 1.5 Mmtcc is not ideal. The 5 Mmtcc production option is also not attractive when considering the current supply and demand dynamics in the world metallurgical coal market.

Line Creek can realize an increase in annual production, a decrease in total operating unit costs, and an increase in the 10 year net present value of the operation along with a strong benefit to capital cost ratio by upgrading the heavy media wash plant circuit. The 4 Mmtcc option is represents the most stable low risk option to elevate the value of the Line Creek Operation asset for Teck.

As outlined previously, the equipment required and the installation schedule to increase the annual production to 4 Mmtcc can be accomplished as soon as the 2016 summer shut down. This will allow Teck to realize the benefits of the opportunity by the third quarter of 2016. Furthermore, the installation can be accomplished during a routine length shut down of no more than 10 days.

A full environment scan of the increase to 4 Mmtcc is required to ensure that Teck maintains its social and environmental licence to operate in the Elk Valley. In order for the full benefit to be realized, the scan must be completed by the end of the first quarter 2016.

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http://center.sustainability.duke.edu/resources/green-facts-consumers/what-largest-fuel-source-electricity-united-states

Appendix

Calculations for Economic Analysis

($000's)

i	n	Year	Case 3.5 Mmtcc input at time zero	Case 3.5 Mmtcc output at time zero	Case 3.5 Mmtcc PV at time zero
8.0%	0	2015	$ 427,000	$ 370,195	$ 56,805
	1	2016	$ 405,093	$ 368,764	$ 36,329
	2	2017	$ 420,096	$ 344,869	$ 75,227
	3	2018	$ 430,654	$ 316,545	$ 114,109
	4	2019	$ 432,198	$ 287,952	$ 144,246
	5	2020	$ 390,655	$ 269,004	$ 121,651
	6	2021	$ 361,717	$ 249,078	$ 112,640
	7	2022	$ 334,923	$ 230,627	$ 104,296
	8	2023	$ 310,114	$ 213,544	$ 96,570
	9	2024	$ 287,143	$ 197,726	$ 89,417
	10	2025	$ 265,873	$ 183,080	$ 82,794
				NPV	$ 1,034,084

($000's)

i	n	Year	Case 4.0 Mmtcc input at time zero	Case 4.0 Mmtcc output at time zero	Case 4.0 Mmtcc PV at time zero
8.0%	0	2015	$ 427,000	$ 370,195	$ 56,805
12.6%	1	2016	$ 434,028	$ 390,512	$ 43,516
	2	2017	$ 480,110	$ 377,915	$ 102,195
	3	2018	$ 492,176	$ 346,746	$ 145,430
	4	2019	$ 493,940	$ 315,181	$ 178,759
	5	2020	$ 446,463	$ 294,556	$ 151,906
	6	2021	$ 413,391	$ 272,737	$ 140,654
	7	2022	$ 382,770	$ 252,535	$ 130,235
	8	2023	$ 354,416	$ 233,828	$ 120,588
	9	2024	$ 328,163	$ 216,508	$ 111,656
	10	2025	$ 303,855	$ 200,470	$ 103,385
				NPV	$ 1,285,129
				Difference from 3.5 Mmtcc Case	$ 251,045
				Benefit to cost ratio	55.8

($000's)

i	n	Year	Case 5.0 Mmtcc input at time zero	Case 5.0 Mmtcc output at time zero	Case 5.0 Mmtcc PV at time zero
8.0%	0	2015	$ 427,000	$ 370,195	$ 56,805
16.9%	1	2016	$ 434,028	$ 394,215	$ 39,813
	2	2017	$ 540,123	$ 503,086	$ 37,037
	3	2018	$ 615,220	$ 416,603	$ 198,617
	4	2019	$ 617,425	$ 378,393	$ 239,032
	5	2020	$ 558,078	$ 353,767	$ 204,311
	6	2021	$ 516,739	$ 327,562	$ 189,177
	7	2022	$ 478,462	$ 303,298	$ 175,164
	8	2023	$ 443,020	$ 280,832	$ 162,189
	9	2024	$ 410,204	$ 260,029	$ 150,175
	10	2025	$ 379,819	$ 240,768	$ 139,051
				NPV	$ 1,591,369
				Difference from 3.5 Mmtcc Case	$ 557,285
				Benefit to cost ratio	5.1

Figure A1 Economic Present Value Calculation for Increasing Coal Sale Price

($000's)

i	n	Year	Case 3.5 Mmtcc input at time zero	Case 3.5 Mmtcc output at time zero	Case 3.5 Mmtcc PV at time zero
8.0%	0	2015	$ 427,000	$ 370,195	$ 56,805
	1	2016	$ 395,370	$ 368,764	$ 26,606
	2	2017	$ 366,084	$ 344,869	$ 21,215
	3	2018	$ 338,966	$ 316,545	$ 22,422
	4	2019	$ 313,858	$ 287,952	$ 25,906
	5	2020	$ 290,609	$ 269,004	$ 21,605
	6	2021	$ 269,082	$ 249,078	$ 20,005
	7	2022	$ 249,150	$ 230,627	$ 18,523
	8	2023	$ 230,695	$ 213,544	$ 17,151
	9	2024	$ 213,606	$ 197,726	$ 15,880
	10	2025	$ 197,784	$ 183,080	$ 14,704
				NPV	$ 260,822

($000's)

i	n	Year	Case 4.0 Mmtcc input at time zero	Case 4.0 Mmtcc output at time zero	Case 4.0 Mmtcc PV at time zero
8.0%	0	2015	$ 427,000	$ 370,195	$ 56,805
20.7%	1	2016	$ 423,611	$ 390,512	$ 33,100
	2	2017	$ 418,381	$ 377,915	$ 40,466
	3	2018	$ 387,390	$ 346,746	$ 40,644
	4	2019	$ 358,695	$ 315,181	$ 43,514
	5	2020	$ 332,125	$ 294,556	$ 37,568
	6	2021	$ 307,523	$ 272,737	$ 34,785
	7	2022	$ 284,743	$ 252,535	$ 32,209
	8	2023	$ 263,651	$ 233,828	$ 29,823
	9	2024	$ 244,121	$ 216,508	$ 27,614
	10	2025	$ 226,038	$ 200,470	$ 25,568
				NPV	$ 402,096
				Difference from 3.5 Mmtcc Case	$ 141,274
				Benefit to cost ratio	31.4

($000's)

i	n	Year	Case 5.0 Mmtcc input at time zero	Case 5.0 Mmtcc output at time zero	Case 5.0 Mmtcc PV at time zero
8.0%	0	2015	$ 427,000	$ 370,195	$ 56,805
23.7%	1	2016	$ 423,611	$ 394,215	$ 29,396
	2	2017	$ 470,679	$ 503,086	$ (32,407)
	3	2018	$ 484,238	$ 416,603	$ 67,635
	4	2019	$ 448,368	$ 378,393	$ 69,975
	5	2020	$ 415,156	$ 353,767	$ 61,389
	6	2021	$ 384,403	$ 327,562	$ 56,841
	7	2022	$ 355,929	$ 303,298	$ 52,631
	8	2023	$ 329,564	$ 280,832	$ 48,732
	9	2024	$ 305,152	$ 260,029	$ 45,122
	10	2025	$ 282,548	$ 240,768	$ 41,780
				NPV	$ 497,898
				Difference from 3.5 Mmtcc Case	$ 237,076
				Benefit to cost ratio	2.2

Figure A2 Economic Present Value Calculation for Static Coal Sale Price