LOCAL ZINC CONCENTRATE SUPPLY FOR TECK RESOURCES LTD. TRAIL METALLURGICAL COMPLEX

by

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Abstract

The inland location of the Teck smelter in Trail results in high inbound logistics costs for raw materials relative to competitors. 'Local' concentrate supplies (deliverable to Trail directly by rail or truck from the mine site) can mitigate this competitive disadvantage. Teck Resources Ltd. needs to support the development of local concentrate supply to improve Trail's profitability and resilience to supply change disruptions.

This paper will make recommendations to change Teck Resources Ltd. strategy with respect to zinc to take advantage of favourable market conditions for zinc and realize more potential from the Trail Metallurgical Complex. The final section will justify options for re-opening of the Pend Oreille mine and present ideas that will make current properties more attractive for development.

Acknowledgements

I would like to acknowledge Teck Resources Ltd. for sponsoring this program and providing me the opportunity to participate. My knowledge of the company was greatly enhanced through the participation of other students from other Teck operations. I would also like to thank to my fellow students for their insight and discussion throughout the program.

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1: Introduction

The aim of this paper is to convince the reader that a change in strategic direction is justified with respect to the zinc business unit at Teck Resources Ltd (Teck). The ultimate solution will be to develop or secure additional concentrate supply for the Trail Metallurgical Complex (Trail). The scope of the analysis includes supply and demand analysis of the zinc market, a review of the culture competitive position of the Trail Metallurgical Complex, and an operating analysis on mines local to Trail. Based on the aforementioned analysis recommendations are made on specific paths for the Trail smelter and the zinc business unit with respect to concentrate supply.

Teck Resources Ltd. is a diversified mining company that produces mined concentrates, refined metals, and metallurgical coal. The company has six main operating units: copper, coal, zinc, energy, exploration, and people. The focus of this paper is on the interactions between the zinc and exploration operating units on the topic of the strategic importance of local zinc concentrate supply to the Trail Metallurgical Complex. 'Local' zinc concentrate supply is defined as a concentrate that can be trucked or delivered by rail without having to move through the port of Vancouver. In a nutshell, this will be beneficial for Trail as there will be another 'locked in' source of concentrate, the concentrate will have reduced shipping charges (compared to concentrates delivered from overseas), there will be reduced congestion at the port of Vancouver, and local concentrate supply should result in lower working capital costs at Trail. From a corporate point of view, current forecasts are for a tightening of the zinc concentrate market. This will ultimately move the cost of smelting concentrates more in the favour of mines making it more profitable to be in the mining business. Corporate will also benefit from the cost structure and steady mine supply for Trail. If Teck Resources Ltd. does not develop the mine, Trail is still a very marketable commodity with respect to other mining companies developing a mine. There will be a certain security knowing that there is a supply agreement with the Trail smelter that will help with mine financing and even cash flow for the operating mine.

Section 2 of this paper provides a brief insight into global demand for zinc followed by the supply of zinc concentrate. This analysis lays the foundation for why continued investment in the zinc business unit will return value to the corporation. As well, Section 2 addresses some of

the issues with respect to how the smelting industry is changing and the influence of Chinese demand for concentrates.

Section 3 describes a brief history of the Trail smelter operations to emphasize the culture of innovation that exists in Trail. This section also looks at how the Trail smelter operating costs compare to other smelters in the world. With Trail being one of the lowest cost smelters in the world, it is ideally suited to capitalize on the newer mines with the potential to come into operation.

Section 4 of the paper moves away from the smelting side of the business towards the mining side. It examines the cost structure for existing local mines that send concentrate to Trail, and the costs mines incur to have their concentrates smelted (or on the opposite side, the revenue the smelter receives from the mine).

Section 5 outlines how new local sources of concentrate aligns with current Teck Resources Ltd. strategy and justify changes to that strategy. The need for a structural change at Trail smelter operations is discussed as well. Structural change would allow Trail smelter operations to better adapt to changing feeds and impurities and allow it to maintain its current competitive edge.

Four options for local concentrate supply for Teck Resources Ltd. are presented for consideration in Section 6: developing a stand-alone mine, developing a smaller mine in the Trail catchment area, working with a third party concentrate supplier, and partnering with a Junior mining company.

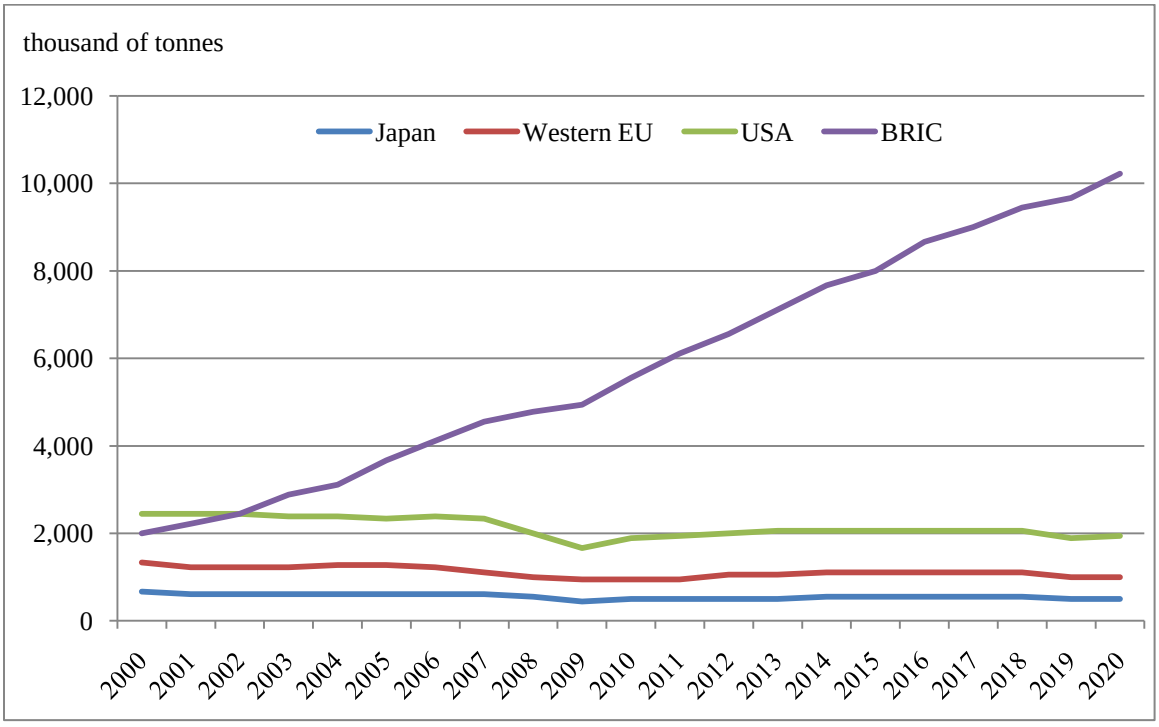
2: Zinc Market

This section evaluates the current market for zinc and relating it to Teck Resources Ltd. current strategy for its zinc business unit. The objective is to justify that the current market indicators are favourable for further investment in this sector. The supply demand forecast for the next 10 years indicates zinc concentrate will be in short supply, at levels inadequate to meet demand, which will result in zinc concentrate price increases. Mines should be able to force favourable treatment terms with downstream purchasers of zinc concentrate as the world's refineries compete for concentrate to meet their refining capacity. Having a secure supply of concentrate for Trail will ensure it can run at capacity during this shortfall in combination with having more concentrate to sell on the market will increase the return to the corporation from the Zinc business unit.

2.1 Zinc Demand

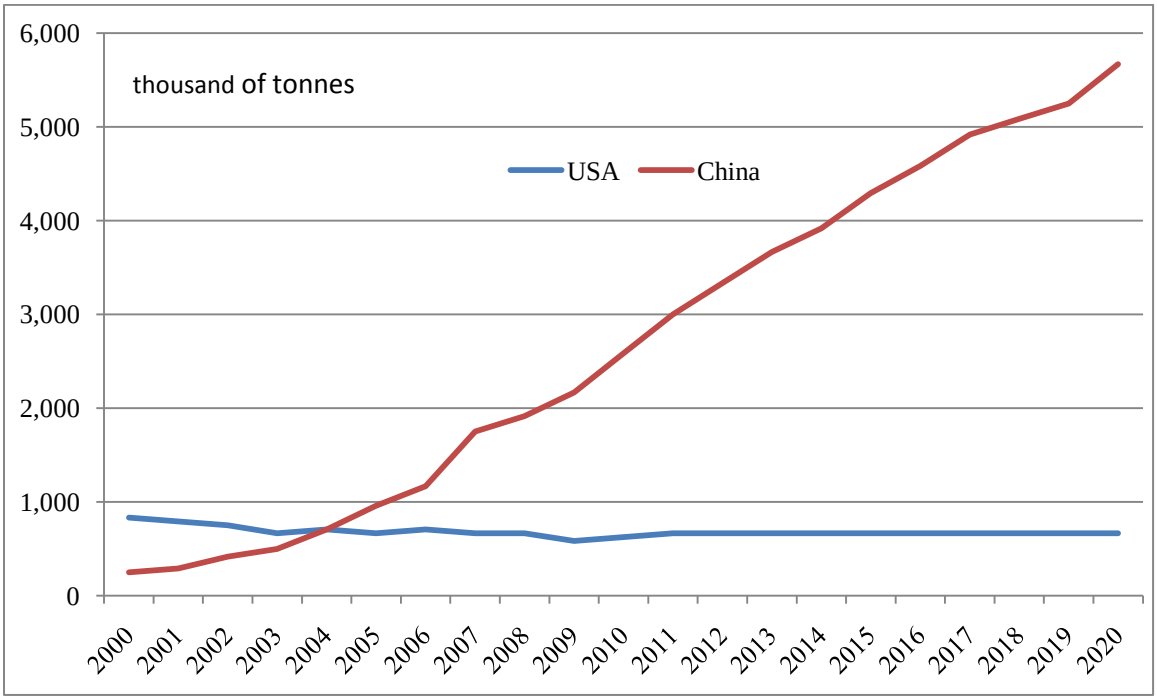
Figure 2.1 shows Brook Hunt's "Stonkus(2010)" analysis for zinc demand by geographic area. Clearly, the consensus is growth will be in the BRIC (Brazil, India, and China) areas of the world. This analysis is supported by analyzing the outlook for industries that use zinc. For example, Brook Hunt "Stonkus(2010)" also analyzed the galvanizing industry (galvanizing refers to coating steel with zinc to improve its corrosion resistance) as one support for their demand analysis. A comparison of the forecast growth for galvanizing in China versus the USA is shown in Figure 2.2. This rosy outlook is supported by the fact that China needs to develop infrastructure to support its current growth rate. Xstrata's latest analysis "Zaldumbide(2010)" of the zinc market is that world demand is recovering and that demand is catching up to production. Their latest estimate is that overall zinc demand will grow at a 4% rate.

Figure 2.1: Zinc Demand Forecast by Brook Hunt (2008)



Source: Andrew Stonkus, "*Zinc and Lead Markets, Investor Day, Nov. 2, 2010*", Teck Resources Ltd.

Figure 2.2: Growth in Galvanizing by Brook Hunt (2008)

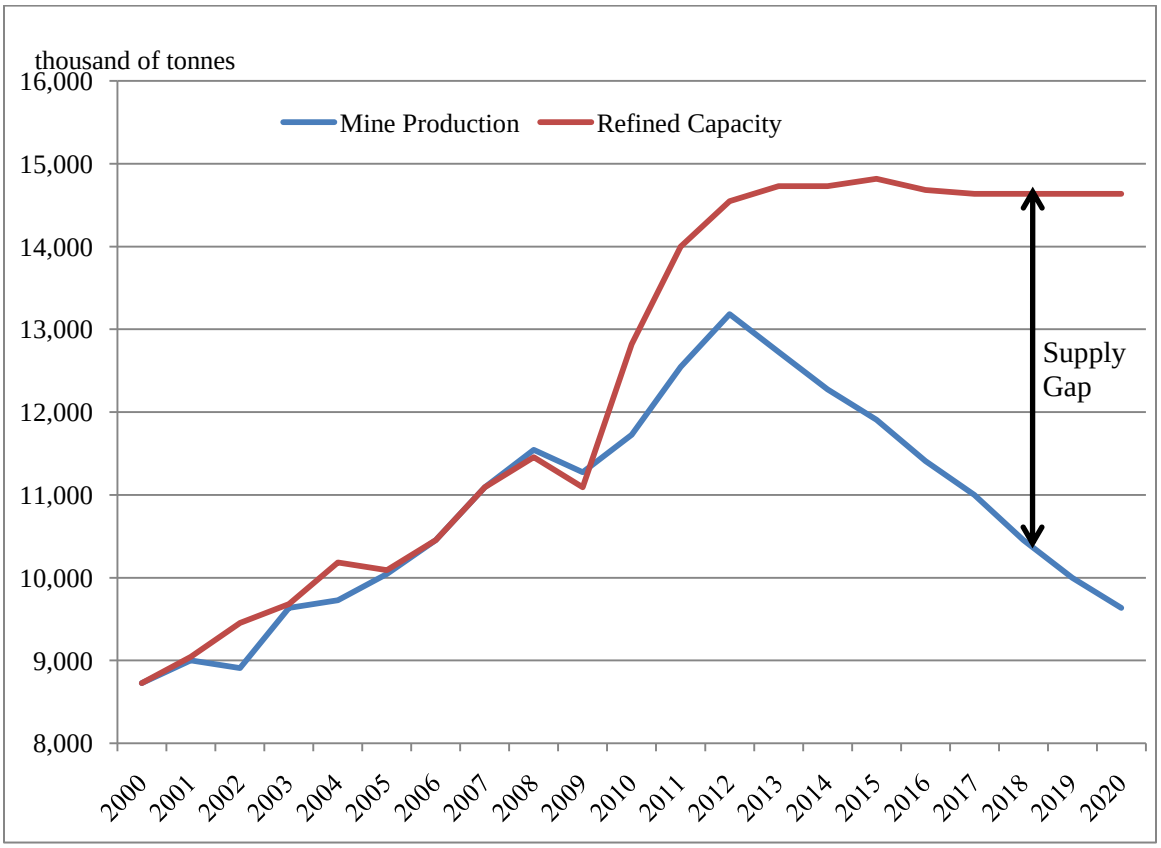


Source: Andrew Stonkus, "*Zinc and Lead Markets, Investor Day, Nov. 2, 2010*", Teck Resources Ltd.

2.2 Zinc Supply

Xstrata's latest analysis "Zaldumbide(2010)" of the zinc market is that by 2016, 1.9 Mt of zinc in concentrate will be removed from the market by mine closures and will be replaced by new projects totalling 0.8 Mt. Teck Resources Ltd. analysis "Stonkus(2010)" is shown in Figure 2.3, which also shows a decreasing supply. Mine production does include projects that are probable at forecasted prices. Mines not currently viable due to factors such as high impurities, remote location, difficult mining conditions, low grade, etc. may become profitable if zinc prices increase as forecasted, helping to reduce the zinc supply gap. However, at this time, the less likely mines identified in the Brook Hunt[1] database will not cover the shortfall.

Figure 2.3: Mine Production and Forecast Refined Capacity by Teck Resources Ltd. and ILZSG (International Lead Zinc Study Group)



Source: Andrew Stonkus, "*Zinc and Lead Markets, Investor Day, Nov. 2, 2010*", Teck Resources Ltd.

[1] "*Zinc and Lead Mine Cost Study, 2008 Edition*", Brook Hunt &Associates Ltd., 2009

At this point, it is worth looking at the world stockpile of zinc and the price history. Figure 2.4 shows the history of zinc stocks on the London Metal Exchange for the first 10 years of this millennia. The price history for the same period is also shown in Figure 2.4. The 25- year average for days of consumption is 39 days; this average was exceeded in early 2010. The price typically follows the inverse of the supply curve. As note above, industry experts are expecting the market to tighten, available stockpiles to drop, and zinc prices to increase.

Figure 2.4: London Metal Exchange Zinc Stocks and Price (source Bloomberg)

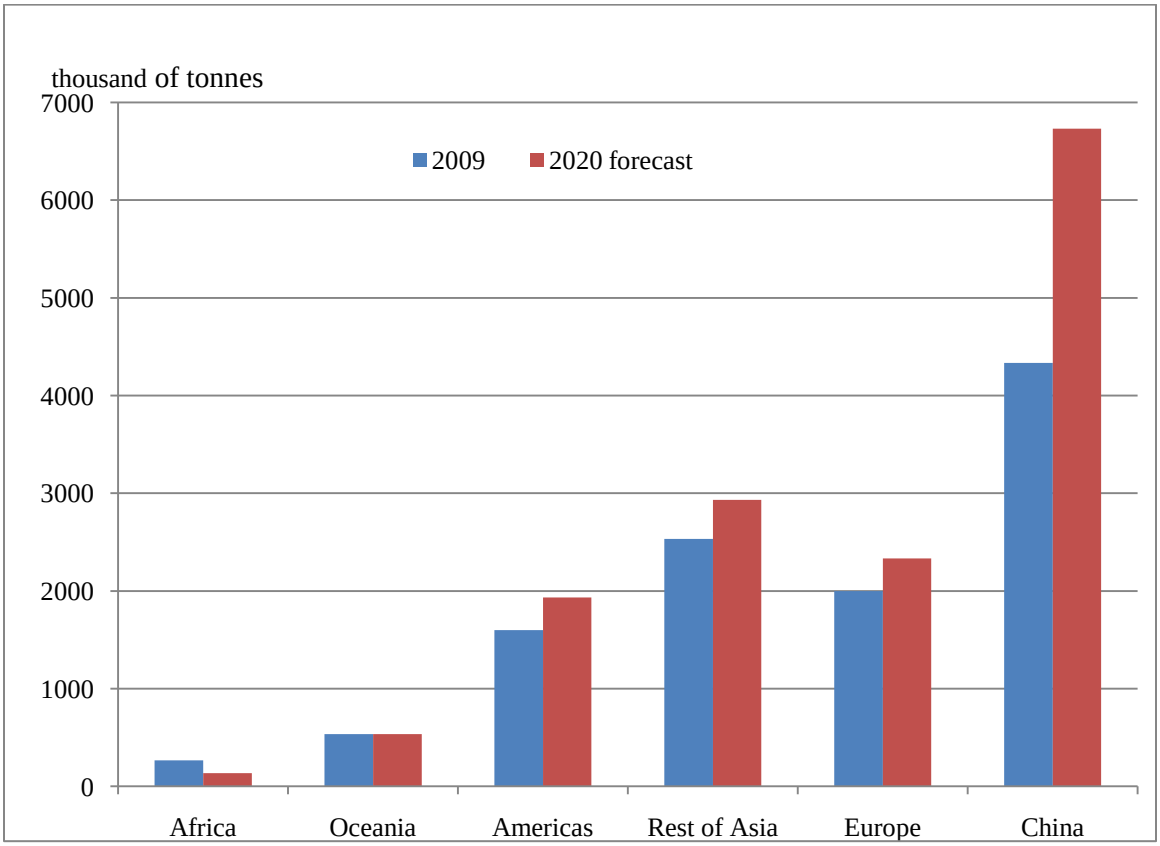
Source: Bloomberg, 2011

2.3 Refinery Demand

The combination of increased consumer demand and reduced concentrate supply will result in increased competition by the smelters for inputs. Mining terms should shift in favour of the mine as smelters compete for a limited resource and result in improved mine returns. Teck

Resources Ltd. forecast "Stonkus(2010)" of mine production and refinery demand is shown in Figures 2.3 and 2.5. Of special note is the large shortfall in China, which re-enforces the fact that Chinese smelter capacity will be increasing to support internal demand in the country. The other issue of note is China will be competing for concentrates and will favour mines that ship on the Pacific: Pacific shipping is also profitable and desirable for the Trail smelter.

Figure 2.5: Refinery Capacity Forecast by Teck Resources Ltd.



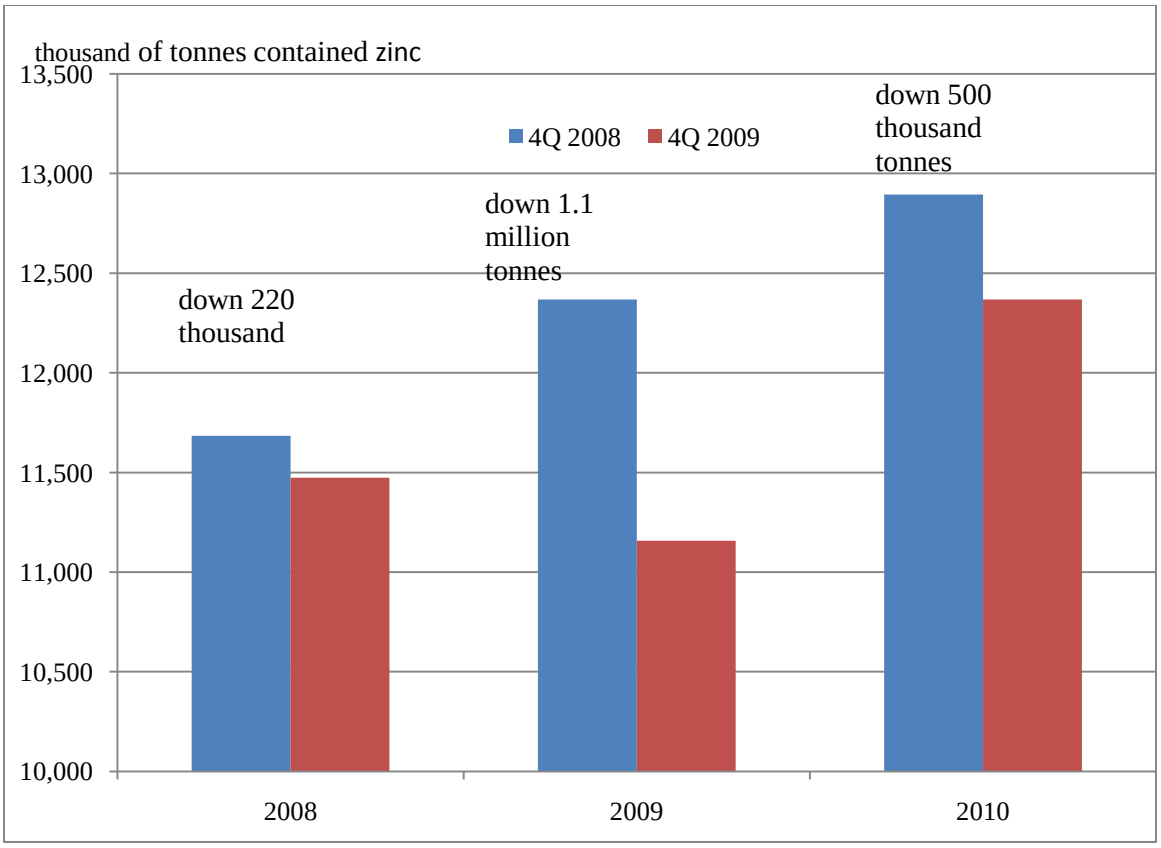
Source: Andrew Stonkus, "*Zinc and Lead Markets, Investor Day, Nov. 2, 2010*", Teck Resources Ltd.

The whole zinc supply chain is changing. Since 2001, 75% of net smelter capacity growth has occurred in China "Deller(2010)". Low construction costs and thus lower capital costs in combination with a booming economy is the main reason for this rapid expansion. As well, since 2000, removal of high cost smelters and their replacement by new or expanded low cost plants has no longer been enough to offset general inflation. This ultimately will reflect that the newer Chinese mills will have higher cost structures. Inflation is also affecting the profitability of mines throughout the world. For example, Canadian mining and milling costs are

50% higher than they were in 2005, due not only to inflation but also to having to mill more tons of concentrate for each unit of metal production. To recover these costs the mines are becoming more and more reliant on other sources of revenues in their concentrates, namely impurities that can be converted to saleable product by the smelters.

Lastly, a word of caution with respect to the accuracies of forecasts: there are many drivers that can affect whether a mine is developed or whether demand predictions come true. As always, hindsight can be beneficial. For example, take Brook Hunt's concentrate production forecast published in Q4 2008 and Q4 2009, as shown in Figure 2.6[2]. In both forecasts, Brook Hunt was optimistic compared to actual (2008) and the Q4 2008.

Figure 2.6: Brook Hunt Global Mine Production Forecasts in Q4 2008 and Q4 2009



Source: "*Zinc taking stock of global mine supply*", MetalBulletin Events 14th Zinc & its Markets, May 2010, Teck Resources Ltd.

[2] "*Zinc taking stock of global mine supply*", MetalBulletin Events 14th Zinc & its Markets, May 2010

2.4 Teck Strategy

Teck Resources Ltd. current strategy with respect to the zinc business unit "Teck(2011)" is 'As the third largest mine producer of zinc in the world, we expect to secure and improve the value of our long life assets in this business by supporting market growth initiatives'. The corporations focus, clearly supported by its own actions, are to focus on world class low cost zinc deposits while supporting demand growth initiatives. Clearly, the Red Dog and Antamina mines[3] support the asset component of the strategy and with Teck Resources Ltd. involvement in the International Zinc Association (IZA) initiative to combat zinc deficiency through the use of zinc fertilizers to improve the yield and nutritional status of crops supporting the market growth component of the strategy.

Clearly, with a fair picture for zinc demand and price to increase, Teck is posed to profit from this upswing. The purpose of this paper is to argue that additional action will be required in order for Teck to increase its profit from the zinc business unit. Teck can benefit from improving its supply of concentrate for the Trail metallurgical complex by either developing a mine or partnering with a company to 'lock in supply' for Trail.

The first news from the 2011 negotiating season for smelter charges is starting to emerge. Treatment charges – charge the smelter charges the mine to treat its concentrate – are down approximately 15%[4,5,6]. These terms were brokered between Teck Resources Ltd. and the Korea Zinc Company. As well, there continues to be downward pressure on price participation and free metal terms in the contract[7]. The International Lead and Zinc Study Group (ILZSG) calculated a zinc surplus of 264,000 ton for 2010. This was down significantly from 446,000 in 2009 due in part to the recovery of the economic upheaval that began in 2008. The market for zinc concentrate will continue to tighten over the next few years shifting negotiating power from the smelters to the miners.

[3] Red Dog Zinc mine in Alaska (Teck owns 100%) and Antamina Copper Zinc mine in Peru (Teck owns 22.5%)

[4] "*Benchmark zinc treatment charges expected in low -$200s, down about 20 percent (IZA Conference)*", Fastmarkets News, Feb. 21, 2011

[5] "*Zinc TCs at $229/t seen as positive for smelters*", Fastmarkets News, Feb. 23, 2011

[6] "*2011 benchmark TC falls 15%*", Platts Metals Week, Feb. 28, 2011

[7] Price participation and free metal terms explained later in the paper

3: Trail Metallurgical Complex

Local zinc concentrate supply can benefit the corporation in two ways. First, selling concentrates to smelters will be more profitable in the coming years, so increasing concentrate supply through mine development should be pursued. Second, having secure supplies of concentrate for the Trail smelting complex will ensure that the smelter can run at capacity. There is a history of innovation at the Trail smelter that has resulted in the development of a very competitive smelter: Trail Operations contributes positively to the corporation's bottom line. This contribution will only increase as zinc prices rise but would be at risk if affected by lack of feed sources. The purpose of this section is to highlight the history and innovation at Trail that has benefited from local mines and resulted in a smelter with multiple revenue streams that ultimately contributes positively to the corporation.

3.1 History and Current Status

The Trail smelter has benefited from entrepreneurial spirit, an abundance of local concentrate supply, and innovative metallurgists to develop into a world-class smelter that is able to convert concentrates from all over the world into a myriad of products. An entrepreneur and mining engineer named F. Augustus Heinz built the original smelter, which began operation in 1896 as a copper gold smelter to treat ore from the nearby Rossland mines. The Canadian Pacific Railway (C.P.R.) purchased the smelter in March of 1898, not to get into the smelting business but to secure the railway charter west to the Okanagan. From this point onwards, the smelter has outlived six smelters in British Columbia due to innovation and association with local mines.

The smelter has benefited from many local mines, with concentrate delivered to the smelter by the C.P.R. rail lines. The feed for the smelter has come from the Slocan mining district, the Sullivan mine in Kimberley, the Bluebell mine on Kootenay lake, the HB mine in Salmo, the Pine Point mine in the Northwest Territories, and the Pend Oreille mine in Washington state to name a few.

With the purchase by the C.P.R., the smelter began its history of innovation in the smelting industry. The first electrolytic lead refinery was built in 1901 to treat ore from the nearby Slocan mining district. The Sullivan mine, a lead zinc mine, began operation in 1910 by

shipping hand selected lead ore to Trail. The first zinc refinery in Trail was commissioned in 1916 using hand picked zinc ore from the Sullivan mine. In 1920, the process of differential flotation was developed to allow the separation of zinc ore from lead ore. This allowed the increase in production capacity for lead and zinc at the smelter. The company began to convert impurities from the ores into products in the 1920's: cadmium in 1927 and bismuth in 1928. The slag fuming process, pioneered in 1930, allowed the recovery of zinc and other valuable metals from lead furnace slags. Fertilizer production began in 1931 as a by-product of pollution control installed to reduce sulphur emissions. The smelter underwent a major modernization that began in 1977. This included installation of the world's first zinc pressure leach plant, a Cominco designed cell house and the third (and largest) KIVCET[8] lead smelter. Over the period, the company has developed product lines that include fertilizer, sulphuric acid, sulphur dioxide, elemental sulphur, indium, cadmium, silver, gold, zinc, lead, and copper sulphate to take advantage of by-products available in concentrates. The result of the innovation and modernization has allowed the smelter to grow from relying solely on local concentrates to a world-class smelter that treats concentrates from all over the world.

3.2 Competitive Advantage

Due to the cyclic nature of commodity prices, a smelter must be very competitive in terms of overall cost control and revenue generation. The Trail smelter maintains competitiveness due to the following factors:

- Modern, efficient smelter;
- Able to generate multiple revenue streams. Trail does this by converting as much of the incoming concentrates into saleable products;
- Good environmental stewardship. License to operate is very important for Teck Resources Ltd.;
- Good operator utilization; and
- Low cost power. The company purchased West Kootenay Power and Light in 1916. This investment ultimately led to the construction and ownership of the Waneta hydroelectric dam, which is the source of low cost power for the smelter.

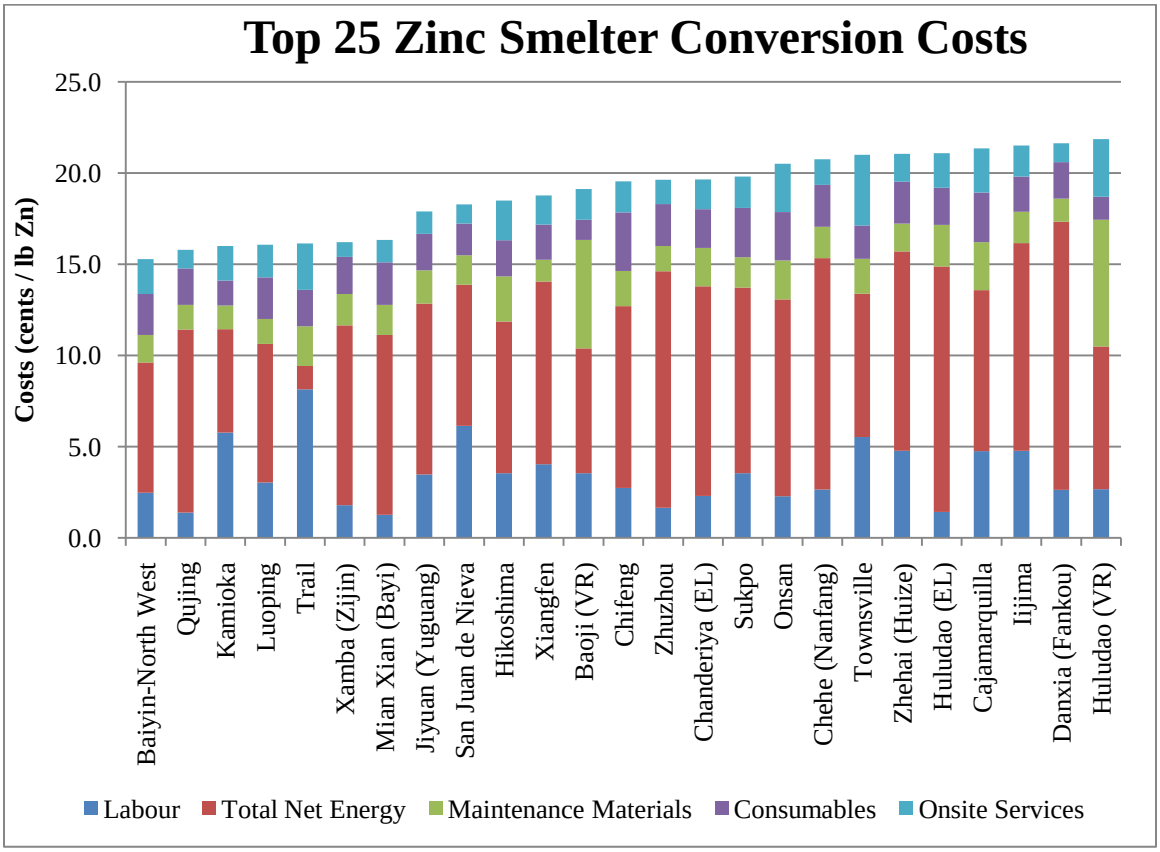
[8] KIVCET is a Russian acronym for oxygen flash smelting of lead, and refers to the technology used at Trail

Brook Hunt publishes a technical and economical study of the primary zinc industry yearly[9]. This analysis is based on operating and revenue data for 77 smelters of the world using a common methodology to create 'apples to apples' comparisons. The top 25 smelters in terms of conversion costs for 2008 are shown in Figure 3.1. Trail Operations ranks fifth in the world in terms of conversion costs. It is clear that this is due to the low cost of power (refining of zinc is power intensive, consuming 3.1 MW hr per tonne of zinc). This competitive advantage is offset by the high labour costs incurred at Trail. Trail's location in North America means labour costs are significantly higher than other parts of the world (15 of the 25 smelters are located in China). The relative position of Trail cost streams in the analysis is summarized in Table 3.1.

On the revenue side, Brook Hunt[8] ranks Trail 14th in the world. This is mainly driven by other downstream benefits, namely derived from the extensive suite of co-products not captured in the main categories. Treatment charges are the charges that smelters charge the mines for processing their ore. The mines are generally responsible for freight to the nearest port to the smelter. The Brook Hunt adjusts the treatment charge to account for the freight required to transfer concentrates to Trail from the nearest port. Clearly, smelters that have tidal locations will have an advantage. Bonus zinc revenue results from the smelter recovering more zinc from the concentrate than Teck paid the mine for at the time of concentrate purchase. In addition to zinc revenue, additional revenue can be derived from other saleable by-products found in the concentrate. In the case of Trail, saleable by-products include lead, silver, gold, copper, and cadmium. The low ranking for sulphur revenues reflects Trail's isolation from major sulphur consuming markets and costs to transport it to market. Other downstream revenue position reflects Trail's ability to generate revenue from other impurities found in the concentrate. These products would include indium, germanium and ferrous granules (tail slag from the lead smelting process). The position of the Trail Smelter relative to the top 25 revenue-generating smelters in the world is shown in Figure 3.2 and the relative position of the revenue streams is shown in table 3.1.

[9] "*Zinc Smelter Study 2008 Edition*", Brook Hunt & Associates Ltd., 2008

Figure 3.1: Conversion Costs for Top 25 Zinc Smelters in 2008 Brook Hunt Analysis



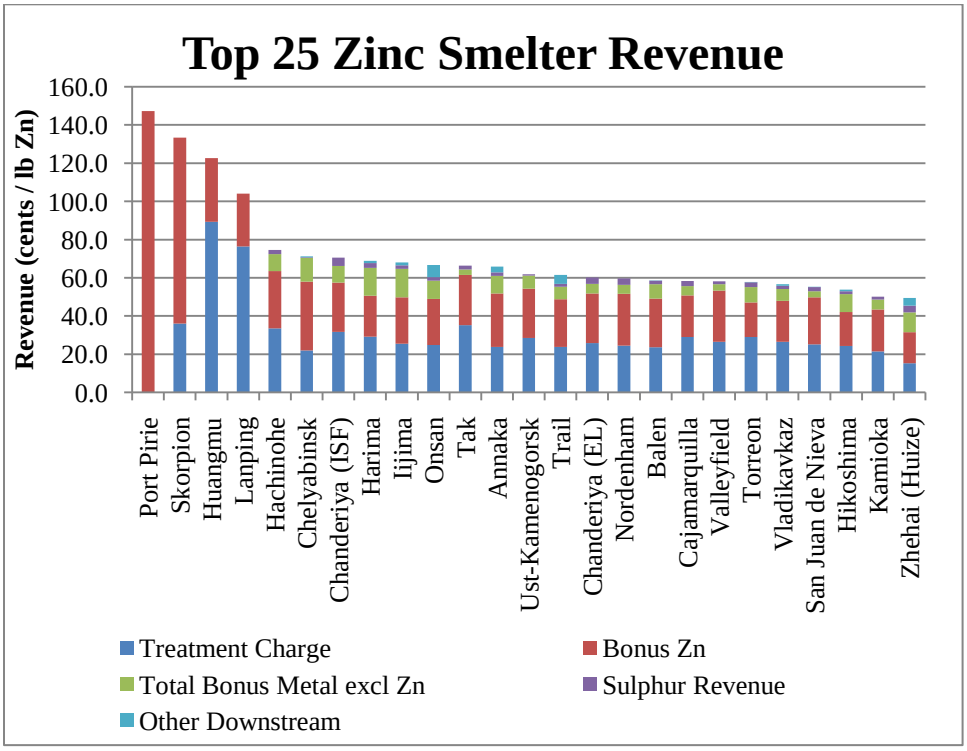
Source: "Zinc Smelter Study 2008 Edition", Brook Hunt & Associates Ltd., 2008

Table 3.1: World Ranking of Trail Smelter for Costs and Revenue Streams in 2008 Brook Hunt Analysis

Costs		Revenue	
Labour	60	Treatment Charge	39
Total Net Energy	1	Bonus Zinc	21
Maintenance Materials	35	Bonus excluding Zinc	20
Consumables	25	Sulphur Revenue	60
Onsite Services	42	Other Downstream	4
Total Conversion Costs	5	Total Revenue	14

Source: "Zinc Smelter Study 2008 Edition", Brook Hunt & Associates Ltd., 2008

Figure 3.2: Revenue Breakdown for the Top 25 Zinc Smelters in 2008 Brook Hunt Analysis



Source: "Zinc Smelter Study 2008 Edition", Brook Hunt & Associates Ltd., 2008

3.3 Trail's Contribution to Teck Resources Ltd.

Trail's operating cost structure has resulted in positive operating profit contributions to Teck Resources. A breakdown of Trail's operating profit for the last 3 years is shown in Table 3.2[10,11,12]. The operating profit contributions of the three main business units for Teck Resources are shown in Table 3.3. Trail's contribution is highlighted, and clearly, there is cause for improvement in profitability at Trail. One must also be careful to realize that the commodity cycles for coal and copper are not in sync with zinc as market conditions for those materials are vastly different.

The focus of the rest of the discussion is how to improve Trail's contribution to Teck Resources Ltd. The Trail Smelter has a successful history of innovation and being a 'first mover' into new markets and technology. This paper will now focus on one initiative to support the above goal, which is how a new 'local' mine would improve the fortunes of Trail. The clear benefits include another source of zinc concentrates, lower transportation costs (and thus improved carbon footprint), reduced congestion and reliance on Vancouver Wharves, and finally lower amounts of working capital tied up in raw material inventories. Teck Resources can support this initiative by either developing a zinc mine or exploring methods to encourage other mining companies to develop a mine in the Trail catchment area. Technical support of the Applied Research and Technology (ART) will also be required, as most new deposits in the area will bring metallurgical challenges during the smelting and refining step.

Teck Resources Ltd. does not currently measure the greenhouse gas (GHG) emissions from material transported to sites[13]. However, they have estimated that the majority of GHG emissions from transporting copper concentrate from the Highland Valley Mine are from ocean transport and not from rail or truck to the port. In 2009, Teck and one of its rail providers have begun to measure GHG emissions from rail transport. Trail's GHG contribution will be higher as rail mileage to the smelter is farther than Highland Valley and even the coalmines in South Eastern British Columbia. The question of whether Trail Operations would be able to report a credit in GHG emissions by using mines closer to the smelter still needs to addressed by the sustainability committee. On the other hand, GHG emissions will obvious be reduced and some benefit applied either to the mining operation or the smelter.

[10] "*2008 Teck Annual Report*"
[11] "*2009 Teck Annual Report*"
[12] "*Teck Reports Unaudited Results for 2010*"
[13] "*2009 Sustainability Report Unearthing Potential*"

From a sustainability point of view, Trail has focused on developing or installing processes to ensure that all constituents of the incoming concentrates are converted to some form of saleable product. The current operation at Trail is not generating any legacy stockpiles of waste materials. Legacy stockpiles are being consumed and the operation is considering treating other smelters waste if terms are desirable.

Table 3.2: Operating Profit for Trail Operations

	2008	2009	2010
Production ('000 tonnes)			
Zinc	269.9	239.9	278.3
Lead	85.0	72.6	71.5
Income Statement ($ in millions)			
Revenue			
Metals	1,392	1,162	1,437
Surplus Power	50	28	10
Total Revenue	**1,442**	**1,190**	**1,447**
Costs of Sales			
Concentrate Purchases	785	656	847
Operating Costs	352	325	374
Distribution Costs	97	87	92
Total Costs	**1,234**	**1,068**	**1,313**
Operating Profit before Depreciation and Amortization	**208**	**122**	**134**
Depreciation and Amortization	51	52	49
Operating Profit	**157**	**70**	**85**

Source: "*2008 Teck Annual Report*", "*2009 Teck Annual Report*", "*Teck Reports Unaudited Results for 2010*"

Table 3.3: Operating Profit from Teck Resources Ltd. Business Units

($ in Millions)	2008	2009	2010
Operating Profit			
Copper	882	1,002	1,289
Coal	1,160	1,278	1,690
Zinc	301	454	576
Total	**2,343**	**2,734**	**3,555**
Percent Trail's Contribution to Zinc Business Unit	52.2%	15.4%	14.8%
Percent Trail's Contribution to Total Operating Profit	6.7%	2.6%	2.4%

Source: "*2008 Teck Annual Report*", "*2009 Teck Annual Report*", "*Teck Reports Unaudited Results for 2010*"

3.4 Summary on Trail

In summary, the Trail smelter has been a positive contributor to the corporation. It strengths include:

- First quartile competitiveness in the industry. Very good cost efficiency in lead and zinc circuits. It provides valuable insight regarding customers for base metals and base metal concentrates;
- Trail has been successful at margin maximization. All parts of the incoming feeds are converted to products and the majority are sold at profits;
- The smelter is building on the 'green' movement with electronic waste treatment to recovery valuable metals; and
- The smelter is a valued corporate citizen in the community. It is a very modern, clean, and aesthetically pleasing facility. It is known as a great place to work. "Belland(2011)"

4: Local Zinc Mines

The purpose of this section is to start to build the basis for finding benefits that can be shared between local zinc mines and the Trail smelter. The concepts with respect to concentrate shipping costs and smelter charges, introduced in the later half of this section, will be used to build the case for developing zinc mines. In conjunction with the previous discussion on Trail smelter costs, we can begin to explore opportunities for savings between mines and the smelter that may aid in improving the business plans for both.

4.1 Cost Structure

The cost structure for mines is similar to that of the smelter in that it includes typical operating costs such as labour, energy, supplies and services required to mine the material and produce the concentrate. These costs are similar to those incurred at the smelter however the mines can be more isolated and have less infrastructure i.e. Red Dog in Alaska versus Lucky Friday in Idaho[14].

The mine is also responsible for freight of the concentrate to the nearest port to the smelter. Freight costs typically involve trucking, rail, shipping and the subsequent loading and unloading of the material. Theses costs vary and depend on where the concentrate is to be delivered. For example, the Red Dog mine would be required to deliver concentrate to the ports of Vancouver for Trail, port of Onsan for the Korea Zinc Smelter and Antwerp for the European smelters. For mines such as Pend Oreille, which are located close to a smelter or better infrastructure, freight costs are lower. Typically, the savings in freight costs by not having to ship to a port would be shared between the smelter and the mine.

Treatment charges are costs that are negotiated with the smelter: these costs reflect payments to the smelter to convert the concentrate to more refined product. The treatment terms can be complex: they are typically negotiated yearly and vary with changing zinc price. The terms include a flat fee per ton of concentrate treated. This fee is corrected for payable zinc i.e. typically a smelter pays for 85% of the contained zinc; if the smelter recovers more than 85%

[14] The Red Dog mine is located in Alaska. The location requires the mine generate its own power and install their own shipping port. In comparison, Lucky Friday is closer to the electrical grid and can ship using established highways.

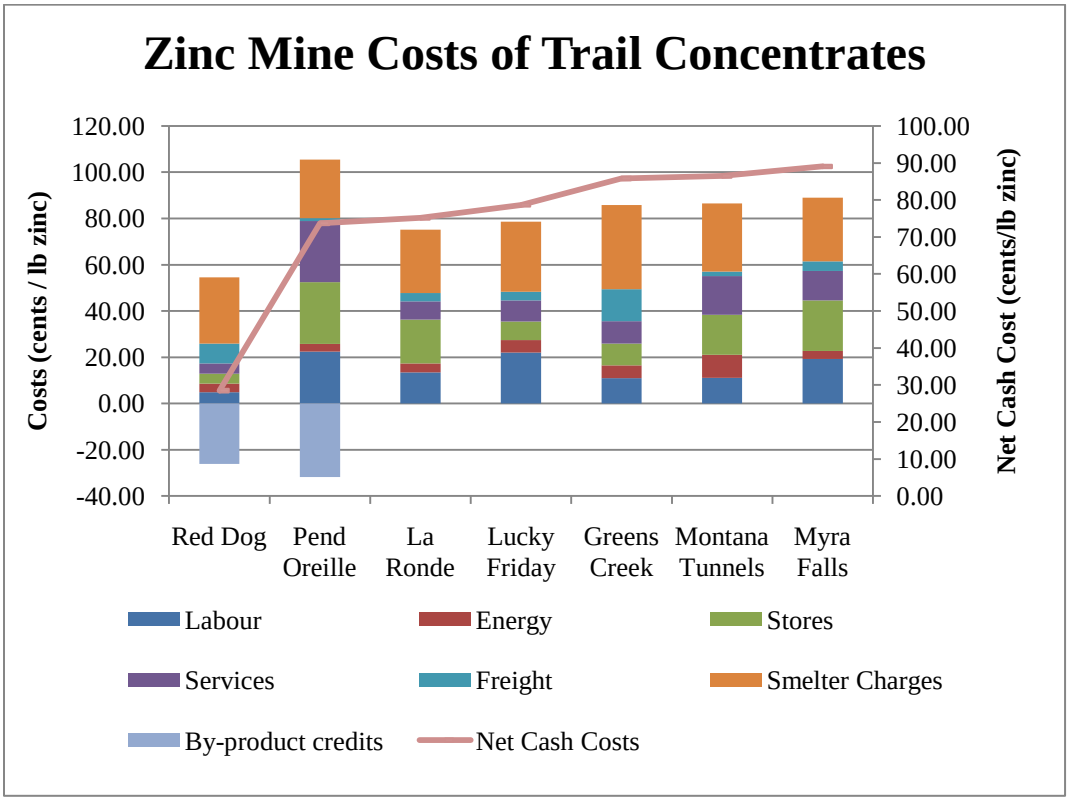
zinc, this difference becomes a 'bonus zinc', as described in the smelter analysis. The mine may also be charged penalties for impurities in the concentrate. These charges compensate the smelter for the cost of handling impurities to meet product specifications and environmental standards.

On the flip side, the mine may benefit from credits from the smelter for certain saleable by-products that the smelter recovers during processing. Each by-product will have its own terms. Typically, zinc mines produce lead, silver, gold, and sometimes copper. Market conditions may drive other metals to be included in the by-product stream, such as indium.

Cost summaries for select 'local' mines that have supplied concentrate to the Trail smelter are shown Figure 4.1[15]. Teck Resources Ltd. Red Dog mine is very competitive on a cents per pound basis, mostly because of ore grade and size of operation (1,074 millions pounds of payable zinc versus 64 million pounds for Pend Oreille). Also, note that Pend Oreille, located 80 kilometres from the Trail smelter, has very low transportation costs relative to other mines (1.3 cents/lb versus an average of 5.1 cents per pound). Lucky Friday and Montana Tunnels are also mines close by in the Pacific Northwest area of the United States. The largest mine cost is also the smelter charges (average charge is 29 cents per pound zinc). Both transportation and smelter charges (in the form of by-product credits) can be leveraged into a partnership to encourage mine development.

[15] "*Lead Zinc Mine Cost Study 2008Edition*", Brook Hunt & Associates Ltd., 2009

Figure 4.1: Cost Summary of Select 'Local' Mines in 2008 Brook Hunt Analysis



Source: "Lead Zinc Mine Cost Study 2008 Edition", Brook Hunt & Associates Ltd., 2009

4.2 Smelter Charges

Section 4.1 had a good look at the cost structure for mines; now it is important to look at how charges are arrived at between the mine and the smelter. This section is divided into 3 sections: payable metal and free metal, treatment charges and price participation, and penalties. A sample calculation is shown in Table 4.1 "Stonkus(May2010)". Note that the mine is still responsible to deliver to the nearest port to the smelter. Additional terms are also negotiated that include the period for which the payable metals will be priced. The period typically reflects the time taken to receive and process the concentrate to align the purchase and the sales price of the payable metals.

4.2.1 Payable Metal

Payable metal refers to the percentage of the contained metal that the smelter will pay the mine. The value typically represents the amount of metal a smelter can recover from a

concentrate. If the smelter can recover more than specified, the extra recovery is referred as free metal. Zinc payables are typically in the range of 85%, historically based on recovery from vertical retort furnaces. Most smelters in operation now follow the roast/leach/electrowin technology and recovery can range from 92 to 98% (Brook Hunt estimates the industry average is 94.5%[14]). Silver payable is typically expressed as deduct a certain value of ounces and pay for 70% of the remainder. Depending on the concentrate, gold, lead, copper, indium, germanium might have a portion payable.

4.2.2 Treatment Charges

The treatment charge typically reflects the cost that the smelter incurs to treat a dry metric ton of concentrate and convert it to product. However, supply and demand of concentrates have led to this charge being negotiated between the smelter and mine, typically on an annual basis. The treatment charge is usually 'benchmarked' against a certain zinc price. If the price falls, the treatment charge is de-escalated at an agreed rate. If zinc price rises, the treatment charge is escalated. The de-escalation or escalation is referred to as price participation. Generally, this refers to the mine and the smelter sharing in the price risk. Increased competition for concentrates is slowly eroding the price participation, making it more favourable for the mines.

4.2.3 Penalties

Penalties refer to charges that smelters charge to deal with undesirables in the concentrate. These undesirables will have negative affects on recoveries, product quality or on the quantity of waste removed. Common elements that are penalized include iron, magnesium, arsenic, antimony and calcium. Clearly, it is in the smelter's interest to design robustness in their process to handle these products and the mine's interest to remove as much as possible in their mill.

Table 4.1: Simplified Sample of Zinc Concentrate Contract

Concentrate at 59% zinc, 5 ounce/ton silver, 8.5% iron, and 0.5% magnesium oxide		
Payments		Per DMT
Zinc: 59% x 85% payable = 50.2% x $2,469	=	$1,238.20
Silver: (5 ozs – 3 ozs) x 70% x $34.00 / troy ounce	=	$47.60
Total Payment		**$1,285.80**
Deductions		
Base Treatment Charge ($229/DMT at $2,500/ton)	=	$229.00
Price participation ($2,469 - $2,500) = ($31) x 4 cents/$1.00	=	($1.24)
Penalty: Iron (8.5% - 8%) = 0.5% x $1.50 / 1%	=	$0.75
Penalty: MgO (0.5% - 0.35%) = 0.15% x $2.00 / 0.1%	=	$3.00
Total Deduction		**$231.51**
Invoice Value		$1,054.92

Source: Andrew Stonkus, "*Zinc Concentrate Marketing, Zinc College May 2010*"

4.3 Business Case for local mines

From a local mine perspective, collaborating with the Trail smelter can have several benefits. As discussed earlier, both Trail and the mine will benefit from reduced freight costs. The reduced transportation costs will also lower the carbon footprint for the operations by reducing the amount of greenhouse gases produced due to transportation. The second point, not discussed previously, would involve lowering of working capital costs for both the smelter and the mine. The concentrate would not have to be shipped in large 'bulk' amounts suitable for ocean going vessels and would result in smaller inventories at both the mine sight and the smelter. Thirdly, if a mine has a locked in 'consumer' for its product, especially one of the stature of Teck, financing should be easier to secure. From the Trail point of view, its capacity to treat concentrates should be marketable to local mines that may entice development or securing of longer-term treatment contracts. Finally, there may be opportunities for the mine to tailor its product to better fit into the processing streams at Trail. The benefit could be shared by improved terms in the smelter charges. This concept is explored in later sections (5.5 and 6.5).

5: Teck Strategy

This section explores Teck Resources Ltd. strategy and ultimately whether a local zinc mine would fit within the stated strategic direction for the zinc business unit. New deposits of minerals tend to be in more remote areas, present technological challenges to mine and possibly smelt, often present geopolitical risk, and are subject to more stringent environmental permitting. The importance of fit of new mine proposals within the corporation is critical to whether the project proposal will meet with success or failure. The subsequent sections discuss the advantages of mine development to Teck with focus on metallurgical support for new concentrates, mine location, and mine ownership.

5.1 Current Strategy with Respect to Zinc

Teck's stated strategy with respect to its Zinc business unit is to continue to operate the existing operations and grow the zinc market. The strategy is to focus on large, low cost operations that are world class. From a zinc perspective, the assets are the Antamina copper-zinc mine in Peru and the Red Dog zinc-lead mine in Alaska. Currently Teck does not have any major deposits on the books in North America that would classify as a local mine. The company continues to focus on exploration for zinc, with approximately 23% of the exploration budget devoted to zinc (target areas were Red Dog district, Ireland, and Australia). It is hoped that the following discussion can re-direct some exploration dollars to areas more advantageous to Trail.

From a sustainability point of view, Teck's policy can be summed up in the following paragraphs from the 2009 Sustainability report[16].

"About Teck

Teck is a diversified resource company committed to responsible mining and mineral development with major business units focused on copper, steelmaking coal, zinc and energy. We are headquartered in Vancouver, Canada. We own, or have an interest in, 13 mines in Canada, the USA, Chile and Peru, as well as one metallurgical complex in Canada. We have expertise across the full range of activities related to mining and minerals processing and stewardship, including exploration, development, smelting, refining, safety, environmental protection, product stewardship, recycling and research. Teck is actively exploring in the Americas, Asia Pacific, Europe and Africa".

[16] "*2009 Sustainability Report Unearthing Potential*"

"We are committed to creating value for our shareholders and to creating products that have utility for society while continually improving our performance as a responsible corporate citizen and a leader in our industry. We pursue development of new technologies that make mining and resource stewardship more economically and environmentally sustainable and strive to be a Partner of Choice wherever we operate and with whomever we are associated" (page: 6).

There are some key terms in the above statement. First, the company expresses its interest in exploration, mine development, product stewardship, research, and environmental protection. Teck Resources Ltd. demonstrates these beliefs through their actions. This does make them a 'marketable commodity' as a partner of choice for mining operations. Teck does have a long history of successful joint ventures. Norman Keevil, chairman for Teck Resources Ltd. was quoted in a speech to Society of Exploration Geophysicists on May 15, 2006: 'In summary, 13 of the last 15 mines we have built are joint ventures or partnerships, with a total of 16 different partners. Some of these were the result of pre-existing arrangements, others were earn-ins on third party discoveries, and others were designed to share the risk on new ventures that might have been too much for us at the given time. A common thread is being able to be opportunistic when the chance occurs, - and having a reputation as an acceptable partner who can provide solid engineering and fair dealing.' It is clear from reading the history of Teck that the corporation had moved from a smaller company towards the much larger company that it is today.

The second statement is the company strives to be the 'Partner of Choice' wherever they operate. There are several reasons why the last statement is important: first, it can be interpreted that Teck will work with other companies to go through the steps to develop a mine. These steps, which include, mineral exploration, deposit evaluation, mine planning, mine development and operation, and mine closure. As well, Teck does bring a lot of expertise for developing mines in different communities.

The point that needs to be stressed is taking the next step with respect to zinc opportunities. One might argue that current London Metal Exchange stocks are too high and that there is time to act however, it takes time to fully evaluate alternatives. Teck has been successful at timing markets for purchases in copper and coal (but has also been negatively affected by major economic downturns).

5.2 Proposed Strategic Initiative for Teck Resources

The 2009 Annual report begins with the following quote from Norman B. Keevil[17]: "The three keys to any successful mining company are its ore reserves, people, and financial strength"(page: 4). This paper deals with improving our outlook on all three aspects. First, local ore sources will increase our reserves. Second, current market conditions will be favourable for increasing Teck Resources Ltd. financial strength through mine development and securing feeds for Trail, and finally Teck has the people with the skills to develop mines and operate smelters. Project development will keep current employees and attract new ones looking for the challenges of mine development and operation, especially in Canada. This section looks at the strategic forces that are successfully addressed by looking at local zinc supply and how they have good fit for Teck.

A tightening market for concentrates is forecast. This will increase rivalry for ore supplies. Demand in China is expected to increase at larger rate than its domestic production and thus it will be forced to secure supply outside their country. Section 6 examines a selection of probable local mines. Of these identified properties, Chinese companies have taken a position in approximately 42 % of the available reserves. As a comparison, the next largest positions are Teck at 9% (Red Dog is not included as it is already operating even though there is potential for increasing the reserve base) and Korea Zinc at 6%. Based on this analysis, Teck must be aware that the Chinese companies are challenging in Teck's prime area of operation.

When the current market forecasts become fact, there should be an ample supply of customers for a local zinc mines ore. Market predictions are for a shortfall in refined zinc and a shortfall in concentrate production. This will result in an increase zinc price and downward pressure on smelting terms. Both of these will favour mines but only the increased price will be a benefit for Trail. Changes in smelting terms will have a negative affect on the profitability of all smelters and the smelter will be required to continue to become efficient. Current research by the Teck concentrate business unit is that the revenue sharing portion of zinc treatment contract will be eroded to levels seen in the copper industry. Copper miners receive about 95% of the contained value in a concentrate versus about 67% for zinc miners (albeit the technologies and recoveries are slightly different). Investment in technical programs to improve efficiency, environmental performance, and development of co-product stream will be required to keep Trail in its current cost position.

[17] "*2009 Teck Annual Report*"

From the supply side, it is always good to have control over a certain portion of the available supply. If the market predictions are wrong or something unforeseen happens (global meltdown), then concentrate suppliers will be required to reduce supply. In some cases, this is difficult financially but in a diversified mining company like Teck, the financial resources could be available to support the initiative.

Teck has already engaged in the substitute market for the Trail smelter. The recycling of electronic waste as well recycled batteries is now a major input stream to Trail. However, the smelter will still need carrier metal to carry impurities to their respective recovery steps with in the smelter. Thus, the need for concentrate will remain, as some primary source will always be required at the smelter to aid in the treatment of 'urban'[18] ores. From a marketing point of view, there are no major substitutes to zinc in the construction business. This is the main area of growth forecast as the BRIC countries develop and install infrastructure that uses galvanized zinc such as roads and buildings.

The main strategic question is whether to let new entrants into the mining business or take a role from influencing to total control of the properties. This obviously would be done by deciding to enter into exclusive supply contracts with mine developers through to investing in their companies to collaborating and aiding in the mine development or to taking an ownership role. Many of the potential entrants are 'junior' mining companies who desire to grow their companies through identifying and developing mining properties. Teck Resources Ltd. has followed the same model to grow to the largest mining company in Canada. However, the 'juniors' will experience several barriers: capital supply, development know how, and access to markets. Teck can leverage all of these aspects as incentives to potential partners or take a controlling interest in these mining properties.

Teck Resources Ltd. was named to the Dow Sustainability index in 2008. From the corporate social responsibility point of view, involving Teck in a project will ensure that projects are developed in a sustainable manner. The larger interest that Teck takes in a property, the more it will be able to guarantee that the projects meets its own sustainability objectives. This will also help secure financing and further cement that Teck is a 'partner of choice'.

The answer to the question on whether additional mine capacity would be a good fit for Teck Resources Ltd. is obviously "Yes". The former Cominco was built on the concept of smelter/mine fits, with the majority of mines being local. As well, Teck has positioned itself as a

[18] 'Urban' ore refers to the currently recycling of electronic waste at Trail

partner of choice through its actions and company building that has gone on in the recent past. The company continues to demonstrate that it has the proper discipline to develop good properties. The existing mine properties, as well as the smelting complex, are great training grounds to develop skills in the work force required to operate a successful mine.

However, the amount of mining discoveries per dollar of exploration spending is decreasing. This in part is due to economic conditions limiting spending but also due to the complexity of new deposits – deposit complexity in combination with location and difficulty to mine. The smaller number of discoveries can increase the price of obtaining the complete rights to the deposit. It is important to market Teck's strengths – technology, experience, access to capital, environmental leadership, and a market leader for concentrate and metal – to the owners of the properties to become a partner in developing the mine.

Teck Resources Ltd. needs to update its strategy to include growing zinc supply. This will be attainable in a sustainable way by leveraging the core strengths of the company to become the partner of choice. Teck can add value to its shareholders and ultimately the consumers of zinc by pursuing this strategy.

5.3 Alternative Strategy

The alternative strategy not mentioned above is to continue with the status quo: Trail is receiving a portion of Red Dog concentrate and sourcing the rest of their concentrate needs on the open market. As mentioned earlier, this will become increasingly difficult as competition increases from producing mines. Trail will still have to deal with port congestion bringing concentrate in. As well, concentrates with desirable impurities will be increasingly difficult to obtain and competition may further erode the 'free metal' obtained from these ores.

5.4 Junior Mining Companies

Junior mining companies are typically small companies that are involved in the venture capital market. They are often not large enough to develop the mine themselves and instead are involved in ventures that are more speculative. They often are involved in grass roots exploration or with projects that do not have a lot of definition due to a lack of sampling. Junior companies can also 'earn into' projects by taking over the exploration program for the property. The

ultimate goal is to define the deposit, hopefully large enough to be a mine, and develop a rough mine and treatment plan.

From a strategic point of view, it is very important for Teck to monitor junior company exploration activity "Agg(2011)". First, they can provide insight into what is happening locally. The exploration market tends to be very speculative and the juniors are always looking for properties, investors, and possibly partners as they try to increase their shareholder's wealth. This could be important as they may have valuable information for other elements of interest to Teck i.e. gold, copper, coal. Keeping 'an ear to the ground' can provide insight into the current markets, which of our competitors are actively looking for deposits, and potentially allow us to get in early if Teck feels that a certain deposit has high potential to be a profitable mine. By getting involved earlier with these companies, we could gain valuable insight to what constituents are in the potential deposits. This could aid in our providing value with milling experience or give guidance to the smelter for potential impurities that may result. Options used successfully in the past include offering financing either through direct cash injection in trade for a share of the deposit or buying shares in the company. This essentially spreads the risk between different players but also reduces the individual rewards.

5.5 Teck Strategy for Applied Research and Technology/Business Development Groups

The Trail smelter has always maintained a strong 'technical group'. This has enabled the smelter to maintain its competitive advantage. As well, Trail technical resources are divided mainly into two groups: production support and business development. The production support group is focused on small technological innovation on the day-to-day smelting processes. The business development group is focussed on new products to improve the 'bottom line'. Teck Resources Ltd. 'Applied Research and Technology' (ART) group had its beginnings supporting the Trail Smelter. It has now branched out and does support for all operations. Moving forward there has to be a concerted effort by all three groups to address changes in concentrates coming into the smelter. The first mandate should be to anticipate changes to the incoming feeds and work on solutions. The ART group is best suited to this as they are already doing work at current zinc mines and are best focussed at 'blue sky' solutions to problems. Ultimately, the exploration group has involved ART in the initial process and mine development as part of their decision on whether to forward projects to the next gating level. The 'Business Development group' should also be involved somewhat in this step as the desired solution to issue will probably involve some

new product. Finally, the technical group needs to be involved, as they ultimately will implement the change into the process.

All three groups (technical support, ART and business development) need to be linked more closely to each other, with regular discussions on what is happening in the grass roots exploration, mine project and development, to anticipate what will ultimately be arriving at the smelter. The information learned can also be used to support the concentrate sales group in selling surplus concentrate on the market (although we anticipate that to be an easy sell in the immediate future). It is proposed that there are regular meetings between the three groups (as well as possibly the exploration and corporate business development groups) to discuss issues with respect to smelting.

5.6 Mine Location

The real estate adage of 'location, location, and location' is also true for mine sites. Most new deposits are located in more remote areas. This ultimately increases the challenge of developing and servicing the mine as well delivering the concentrate to market. This section focuses on the benefits of developing local mines.

The probability that a mines production will be treated at the Trail smelter will increase greatly the closer the mine is located to Trail. This would also include mines where the concentrate has to be transported past Trail to a port on the Pacific Ocean. The obvious main driver will be reduced transportation costs, as was shown in section 4, which can have a significant impact on the cash costs of the mine. These cost savings will also provide good incentive for the mine to deliver to Trail, essentially locking in a concentrate supply.

The second benefit about local mines is that the concentrate delivery chain can be simplified. A Peruvian concentrate bound for Trail must go through many handling steps on its trip from mine to smelter. This process can include trucking or rail (or both) from the mine to the nearest port, loading and unloading onto a ship, the ocean voyage, and rail or truck from the port of Vancouver to Trail (concentrate bound for Trail often touches 3 different railways). The risk of a supply interruption, such as labour disruptions or weather events, increases with the number of handlers and time of transportation for the concentrate. Environmental incidents can have negative consequences for the corporation. Although Teck does not usually take title to the concentrate until it is unloaded at Vancouver, an incident stating concentrate bound for Trail will still have negative impact on public perception. Risk of these hazards is mitigated through larger

concentrate shipments (requiring greater levels of working capital to be tied up in concentrate inventory) and through company business ethics and governance policies.[19]

The final comment on location is the geopolitical risk of a given location. Clearly, development of a mine in Canada or the United States, a process that is time consuming and bureaucratic, is relatively straightforward compared to development in a country where the rule of law is less developed. Teck values anti-corruption practices in foreign entities that they conduct business with. Teck follows the Extractive Industry Transparency Initiative[19] that is directed toward improving transparency and improving the return from extracted minerals to the local populations. The risk of dealing with corrupt entities will be reduced in the North American market. Mining friendly jurisdictions, such as British Columbia, are eager for new development and are focused on improving their permitting processes to reduce bureaucracy while still maintaining environmental standards. From a location point of view, developing local mines will have tangible benefits to a project, including: reduced transportation costs, reliable concentrate supply, stimulation of local economies, and knowledge of strong environmental standards for businesses operating in Canada or the United States.

5.7 Mine Ownership

The benefits of mine ownership is explored in this section. The clear benefit of ownership is control of the resource. In 2006, the Votorantim Metals Cajamarquilla smelter in Peru was unable to run at full rates because they were unable to secure concentrates, even in a market where spot treatment charges were approaching zero dollars (smelter charges were explained in section 4.2). At the time, the country of Peru produced approximately 12 percent of the worlds zinc concentrate and the Cajamarquilla smelter had to watch the concentrate leave the country to other smelters. Teck must also be cognisant that Chinese companies are not afraid to invest in mine prospects in Teck's local jurisdiction to lock in feeds for their smelter. These companies are obviously concerned about securing feeds and willing to risk investment into properties that Teck might not be able to justify under current economical conditions.

Mine ownership would provide benefit to Teck Resources Ltd. as a whole. Vertical integration of concentrate production and supply with smelter operations reduces uncertainty and increases control. Teck would benefit from having a secure buyer for the concentrate, would be able to ship the concentrate to the smelter at reduced cost, and would benefit from the profit made at the smelter. As well, Teck could also control production from the mine to maximize market

[19] "*2009 Sustainability Report Unearthing Potential*"

return to the whole corporation. This maximization could be in terms of timing of concentrate production, settling of labour or supply disruptions, or balancing investment into custom treatment processes for minor impurity recovery at Trail against locked in delivery of concentrate. Local mine ownership would also be viewed favourably by the public sentiment and the political system versus foreign ownership. This is especially true lately, as the Chinese companies appear to be on a resource-buying spree of Canadian resources.

The main drawback to ownership of local mines is that few of the identified deposits in the local catchment area meet Teck's criteria of long life, quality deposits. Teck can use its size advantage to help smaller mining companies develop these properties but could give up critical control with respect to decisions regarding mine development, operating rate, and possibly destination for some of the concentrate. As discussed earlier, these risks could be mitigated through purchase agreements for concentrate in lieu of financing or taking a larger position in the mining company to exert development control. However, concentrate supply could be at risk if the mining companies have other financial constraints or lack the financial liquidity to survive downturns in the market.

Moving forward, if Teck is unable to find deposits of suitable quality and size it must develop an incentive program to help junior mining companies develop their properties and share the benefits with the Trail smelter. These plans may include options such as trading development financing for later deliveries of concentrate, or developing mine-smelter integration models that would allow the mine and smelter to share in the realized benefits from treating the concentrate in the Trail smelter (the later concept is explored further in section 6). However, the corporation will take on additional financial risk, concentrate delivery risk, and/or risk erosion of the benefit from other concentrate contracts that supply to Trail by following this strategy.

The last option that the company could follow is to increase production from existing mines. This is ultimately done though mill expansion but would require a good exploration program to increase reserves at the mine, or planning for early retirement of the asset due to resource depletion. The Red Dog mine, the closest to Trail, has followed this path and has been successful at enlarging their reserve base. A similar argument could be made for selecting the best available deposits and investing in exploration resources to identify further resources that would get the mine above the company's internal hurdle rate.

5.8 Conclusions

The arguments in this chapter are meant to re-enforce the belief that local mine development can fit within the current Teck strategy. The company has a proven history of developing mines on a stand-alone basis or in some form of partnership. Local mine development will benefit the company with increased zinc reserves that could be sold for concentrate or better yet used to keep the Trail smelter operating at full capacity. This can be accomplished while meeting the current sustainability objectives. Local mine development would benefit Teck in the following ways:

- Development of better working relationship between exploration, corporate business development, the applied research and technical group and Trail operations;
- If zinc concentrate expansion is pursued, developing local mines closer to Trail will have bigger benefits, including:
    - developing a mine in a more friendly mining jurisdiction;
    - simplified concentrate delivery;
    - lower transportation costs; and
    - the chance of monitoring and maintaining sustainability targets is increased.

Local mine ownership would be preferred but if suitable properties are not available, the company will have to develop a plan to help smaller mining companies develop their deposits, ultimately for the benefit of both themselves and the Trail smelter. The remainder of the paper will focus on options for local mines and a proposal for encouraging mine development in the Trail catchment area. Ultimately, arguing to ensure that resources are assigned to forwarding local zinc concentrate projects for Teck.

6: Potential Local Mines

Two issues of concern are explored in this section. The first issue is that Teck Resources Ltd. does have zinc resources secured in the local catchment area but does not have any current plans to develop them. The second issue is that other smelters have larger position in the available resources, which indicates more forward thinking by our competitors, and that possibly there is consensus about a shortage in concentrate supply in the coming years. This section will present four options for developing these local properties and explore their fit into Teck Resources Ltd. If there is hesitation about developing these properties, several alternatives are explored to enhance the business case using the Pend Oreille mine as an example.

6.1 Probable Mines in the Trail Catchment Area

Local mines that would fit the local catchment area are shown in Table 6.1[20]. Of the 11 mines noted, Teck has secured approximately 34 Mtonnes of resources. For comparison, Chinese smelters have secured 156 Mtonnes and Korea Zinc 17 Mtonnes. These mines can feasibly come onto the market in the next 10 years. This does indicate that Teck has been forward in investing in properties to secure some future in Zinc in the Trail catchment area. However, the question remains, will they make it into production? As explained in the first section, demand should increase; supply fall and this will result in decreased treatment charges and higher metal prices. This should make mining development more attractive. Also mentioned is that the mines are more remote, more difficult to mine, and potentially more difficult to process at the smelters. There are two recent examples of this the last statement. The first being the development of the Galore Creek copper mine in northern British Columbia by Teck and Nova Gold. Teck essentially put a hold on the development of this mine due to increasing development costs and an appreciating Canadian dollar. These two points essentially moved the project to a marginal payback for Teck. The second example refers to published information that the mines in the Wolverine district (Kudz Ze Kayah as well) have high levels of selenium in the ore. Selenium can be problematic to zinc smelters as it can negatively affect product quality. The smelter typically penalizes the mine for high levels of selenium. However, again market conditions may

[20] "*Lead Zinc Mine Cost Study 2008 Edition*", Brook Hunt & Associates Ltd., 2008

be pressure to reduce the penalty in lieu of getting the contract for the concentrate. In this case, the smelter must be prepared to deal with the impurity, either through dilution or through developing a process to remove it, hopefully as a product and not a waste stream.

Table 6.1: Local Mines in Trail Catchment Area

Mine	Location	Ownership	Current Status
Montana Tunnels	Jefferson City, Montanna, USA	Apollo Gold Corp (50%) and Elkhorn Minerals (50%)	2012, pit Development, care and maintenance
Pend Oreille	Metalaine Falls, Washington, USA	Teck	2012, Care and maintenance
Cirque	Williston Lake, 280 km NE Mackenzie,	Teck (50%) Korea Zinc (50%)	2016, development project
Akie	Williston Lake, 280 km NE Mackenzie	Canada Zinc Metals Corp	Mine plan not fully developed
Ruddock Creek	100 km N NW of Revelstoke	Imperial Metal's Corp, 50% option to Itochu and Mitsui Mining and Smelting Corp	Mine plan not fully developed
Selwyn (Howard's Pass)	E Yukon on border with NWT	Selwyn Resources (50%), Yunnan Chihong Zinc and Germanium Co. Ltd. (50%)	2014, development project
Wolverine	115 km SE Ross river	Yukon Zinc Corporation (China)	2011
Kudz Ze Kayah	115 km SE Ross river	Teck	2020, development project
Bellekeno	330 km N of Whitehorse	Alexco Resources	2011
Sa Dena Hes	46 km N of Watson Lake	Teck (50%) Korea Zinc (50%)	2012, care and maintenance
Pine Point	800 km N of Edmonton	Tamerlane Resources	2014, development project

Table 6.1: Local Zinc Mines (cont'd)

Mine	Route to Trail	Mine Life	Deposit Size (kt)	Concentrate Production	
				Zn (kt)	Pb (kt)
Montana Tunnels	Rail, BN	4	32	5	2
Pend Oreille	Truck	4	4,000	55	10
Cirque	Truck/Rail (CN/CP)	14	32,200	181	133
Akie	Truck/Rail (CN/CP)	?	?	N/A	N/A
Ruddock Creek	Truck/Rail (CN/CP)	?	?	N/A	N/A
Selwyn (Howard's Pass)	Barge/transload to rail at Prince Rupert	18	18	862	193
Wolverine	Barge/transload to rail at Prince Rupert	9	9	28	5
Kudz Ze Kayah	Barge/transload to rail at Prince Rupert	10	10	105	24
Bellekeno	Ship	5	5	4	10
Sa Dena Hes	Truck/transload to rail	4	4	79	15
Pine Point	Rail (CN/CP)	7	7,800	108	43

Source: "Zinc and Lead Mine Cost Study, 2008 Edition", Brook Hunt & Associates Ltd., 2009

The approximate locations of these mines are shown in Appendix A. Appendix A also shows existing rail lines in western Canada. The mines Sa Dena Hes, Montanan Tunnels, and Pend Oreille are currently developed but are on care and maintenance. Montana Tunnels requires extensive modifications to their open pit to continue to mine the ore body. At present metal prices and terms, this work has not begun. Pend Oreille and Sa Dena Hes require improved metal prices and possible smelting terms to return to operation. The rest of the operations are in various states of development. They are small operations with limited life left. The prognosis will probably be to start these up at the peak of a cycle to maximize cash flow and prepare the sights for closing.

6.2 Teck Options

At this point, Teck has four options for exploring local zinc mining "Christopher(2010)". They are:

1. Develop a stand-alone mine. The mine will have to fit Teck's current investment strategy of long life and profitable assets;
2. Develop a smaller mine in the Trail catchment. This project would require higher return. A good example of this would be the Pend Oreille mine;
3. Develop a strategy to provide incentives to third parties to develop their projects in the Trail catchment. Association with Teck can help secure financing as well as guarantee a market for the product; and
4. Partner with third parties to explore and develop projects to take advantage of exploration rights Teck currently holds. A very similar strategy to how the 'Junior' mining companies operate where by Teck can offer ownership rights in trade for developing the work.

Teck Resources Ltd. does have experience with all four options "Keevil(2006). Clearly, option 1 can be reflected in Teck's operation of the Red Dog mine or participating in the operation of the Antamina mine. Both of these mines are large, low cost producers but they reflect two different investment styles: Red Dog was self-financed versus Antamina being a joint venture between four companies[21]. With the cost of mine development increasing, there are benefits to bringing other companies in to help finance the project to help spread the risk. The downside is having to share in the proceeds (as there should be with all good investments) and possible loss of control over development of the asset.

Teck also has experience with option 2 with the Pend Oreille mine. This experience has not been rewarding as the mine has only operated for four years and experienced numerous issues. It is clear that these small mines have to be very profitable, as closure costs can be significant, especially in the days of 'sustainable mining companies'. However, there is further discussion on Pend Oreille later in the text.

Option 3 can involve many different types of incentives, the first being optioning existing mineral properties to 'Junior' companies. In lieu (or as well) of payment, the junior will complete a certain amount of exploration or development of the property. Another option could be a direct cash infusion through share purchase. As well, Teck can offer project management and financing

[21] Antamina is owned by BHP Billiton (33.75%), Xstrata plc (33.75%), Teck Resources (22.5%), and Mitsubishi Corporation (10%)

expertise to the junior in exchange for a portion of the deposit to be allocated to Trail. In all three cases, the company will benefit by being involved early on in a project by having access to metallurgy, mine plan data, and being able to influence development decisions.

Option 4 would involve marketing the concentrate capacity of a facility like to Trail to companies that do not desire to partner with Trail. The company can offer an 'off take' agreement to the mine to agree to purchase a certain volume of concentrate. There is risk to this venture as replacing that concentrate if the mine has production problems can be difficult. As well, if the mine does not have sound financial footing, it could also interfere with supply.

For the sake of closing arguments, the discussion is now focused on options for mine development and integration of the ideas presented in this section.

6.3 Options for Mine Development

The purpose of this section is to convince the reader that it is time to invest Teck time and resources into the zinc business unit with the ultimate goal of developing a local zinc mine. To develop this proposal, this section will present options to make projects more attractive and possibly worth pursuing.

6.3.1 Integrated Economic Model for Zinc

The corporation currently does not have a sensitivity model devoted to evaluating different zinc strategies by estimating their effects on the overall market "Christopher(2011)". This model could provide information and insight into several scenarios that are often raised when the question of mine development is raised. One thing to note is that the zinc business unit is a fully integrated unit that produces both concentrate and refined product. Contrasted to the copper and coal business units, it is also dependent on feeds from third parties. This added complexity needs to be simplified to allow for more informed decisions.

First, the model should provide estimates of the change in zinc price under different concentrate supply scenarios, such as predicting price change in a balanced, oversupplied, and/or undersupplied zinc concentrate market at different points in the future. These questions would be very important when completing risk analysis on projects as the price of zinc will have a strong influence on the project economics. As the company does have market experts in the sales group that currently provide market research and forecast zinc prices for short, medium, and long term planning purposes, this should not prove to be an overly technical challenge.

The model should also integrate economic models that reflect economic profit from the different zinc operations – currently Red Dog, Antamina, and the Trail smelter. This would allow for good scenario planning by allowing the project managers to evaluate different pricing and supply scenarios on the zinc business unit. For example, if the zinc price were to fall 0.5 cents per pound due to development of a new zinc mine, what would be the total effect on the corporation? While this might be easy to calculate on a stand-alone basis for the individual properties, the business unit as a whole might be better off based on the savings from synergies that could result if the Trail smelter is integrated into the scenario. As discussed in the next section, the economic model should take into account all the benefits that the corporation could receive through synergies between the mine and smelter. This section of the model should be relatively easy to assemble, as economic models exist for Trail and probably for the zinc mines.

To make the model work, time needs to be devoted to assemble, test and produce forecasts that can be evaluated to build confidence in the model.

6.3.2 Pend Oreille Mine

This section explores some of the synergies that can be realized by valuing the mine and smelter together. The proposed model should include all forecasted or actual smelter charge terms and penalties. Often, minor impurities that are converted to products by the smelter are not valued in the mine economics or shared by the smelter with the mine. For the sake of discussion, it is necessary to have a look at an existing local mine that Teck Resources Ltd. currently has on care and maintenance. The Pend Oreille mine was re-opened by Teckcominco in 2004. The mine was shutdown in early 2009 due to the sudden downturn in the economy in late 2008. The mine had suffered from variable grades and mill recovery throughout its operation. Figure 6.1 shows the operating profit for the mine published in Teck's annual reports[22,23,24,25]. Not all data is available in the reports and as result, some fields are calculated. As well, the corporation was incurring some one-time charges to reflect its operating costs, operating recoveries, and value of the asset based on current operating conditions.

[22] "*2005 Teckcominco Annual Report*"
[23] "*2006 Teckcominco Annual Report*"
[24] "*2007 Teckcominco Annual Report*"
[25] "*2008 Teck Annual Report*"

Figure 6.1: Pend Oreille Operating Results

	2005	2006	2007	2008
Production ('000 tonnes)				
Zinc	45	34	29	35
Lead	8	5	4	6
Income Statement ($ millions)				
Revenue	54	88	70	41
Operating Costs *	34	36	53	56
Operating Profit before Depreciation, Amortiztation, and Pricing Adjustments	20	52	17	(15)
Depreciation and Amortization	18	14	23	12
Operating Profit	**2**	**38**	**(6)**	**(27)**
Operating costs (cents/lb)	34	48	83	73
Average Zn Price (US cents/lb)	54	154	150	85

* Calculated fields due to unavailability of data

Source: "2005 Teckcominco Annual Report", "2006 Teckcominco Annual Report", "2007 Teckcominco Annual Report", "2008 Teck Annual Report"

Pend Oreille already enjoys very low transportation costs for its concentrates. The cost savings are shared on 50% basis with Trail. Despite this, the mine still struggled to be profitable at very good zinc prices. Figure 6.2 shows sensitivities to smelting terms and applies them to the Pend Oreille model. The sensitivities were calculated using the sample contract shown earlier in the paper. Three likely sensitivities are shown: lower treatment charge, increased zinc price, and increased payable for zinc. The first two scenarios have been discussed in depth. The third could be a similar effect to erosion of the treatment charge due to increased competition. The other note is that Pend Oreille concentrate has very low Fe (less than 3%). This is very beneficial to smelters in that overall zinc recovery will increase. It would not be hard to imagine that the Trail smelter could share in these recovery improvements. Teck Resources would benefit either way, either improved smelter return or Pend Oreille return.

The same argument can be made with respect to the germanium (Ge) content of the concentrate. The Trail smelter is able to recover a portion of this as product. The price for germanium has ranged from $500 to $2,000 per kg in the past 5 years. At $500/kg and a conservative recovery of 50%, the return to Trail would be on average $2 million per year. The

economics of minor impurities and their recoverable values should be taken into account when evaluating the profitability of the property.

Clearly, in this case there is benefit to evaluating the Trail smelter and Pend Oreille together. The upward potential to Teck Resources Ltd. for very realistic changes in prices and terms could be in the range of $6 to 8 million per annum. Operating the mine when Ge prices rise will further increase the return to Teck.

Figure 6.2: Sensitivities to Changes in Concentrate Terms and Affect on Pend Oreille Income Statement

Pend Oreille Sensitivity ($ per tonne concnetrate)				
- $30/tonne Treatment Charge	30.46			
+ $0.10 zn Price	19.16			
+ 2 % Payable	30.92			
	2005	2006	2007	2008
Potential Op Profit Increase (millions)				
- $30/tonne Treatment Charge	2.3	1.8	1.5	1.8
+ $0.10 zn Price	1.5	1.1	0.9	1.1
+ 2 % Payable	2.4	1.8	1.5	1.8
Total	6.1	4.6	4.0	4.8

6.3.3 Bundling of Projects

The idea explored in this section is to bundle projects with close geographic ties to build a project that would meet Teck's current development criteria. The goal would be to produce projects with positive net present values (NPV) by increasing the overall size of the deposit, sharing one processing mill for several mines, or possible combining less profitable deposits with ones of a higher grade to get both deposits at an investment level. Combining mines in a mining district into one big mine would provide the critical mass required to get the unit costs down and spread development costs over a longer mine life. Sharing a common milling facility, either through a joint venture or creation of a separate company is another way to reduce capital for smaller mining projects. The last point could be beneficial by using selective mine planning to maximize cash flows early in a project by mining higher grade deposits and then finishing with the lower grade portion of the deposits.

It is obvious that bundling of projects can increase the value of projects. This value can be realized by either selling Teck's interest for a profit or by attempting to create value for the

corporation through development of the property. Obviously, the chance of sole ownership would be diminished under this strategy and could present other issues of joint ownership that could increase the resistance to develop the project. Teck has developed into a much more sophisticated mining entity than it once was when Dr. Keevil was building the company through joint ventures. As well, the shareholders will be a lot more discerning when it comes to choosing investment partners. Once the idea of joint venture is raised, several high level issues come to mind that would have to be resolved. First, would be that the company have similar corporate governance ideals to Teck. These ideals include environment, health, and safety to name a few. Second, would the company have enough capital to complete the job right and not take critical shortcuts if cash was in short supply? Finally, does the company have enough human capital to develop the project? It is my perception that Teck would like to be the partner of choice but would also like to control and operate the development to address these concerns. This was evident in the deal with NovaGold Resources Inc. to develop the Galore Creek mine. Teck was responsible for financing and operating the mine and ultimately put a halt on the project when costs were escalating to the point where the project would not be profitable. Teck would also want a say on controlling production levels to maximize their entire concentrate portfolio.

From Table 6.1, there are three obvious bundling opportunities, based on geographical location. They are: combining the Cirque and Akie properties, combining the Wolverine and Kudz Ze Kayah, and the Selwyn basin. Other than the Selwyn basin, multiple ownership exists in each of the areas. Although the valuations would be reasonably abstract, evaluation of the owners of these properties would need to be carried out to see if the owners of these deposits can fit with Teck or whether Teck should look for ways to take controlling positions. The benefit of multiple owners is that access to capital can be shared by several companies. However, investment decisions could be more complex as two sets of board of directors would have to be convinced of both a project's merit and a functional operating structure (who is making the day-to-day decisions). Again leveraging the benefit of a nearby smelter i.e. financing in lieu of future concentrate deliveries, could help alleviate those fears and favour Teck as an operator.

6.3.4 Take a Chance

The discussion will now explore what all optimists in exploration groups would like their companies to embrace: take a chance on investing in an uncertain future outcome with upward potential for the company. This section is more concerned with projects that are not as far along the development chain as the aforementioned projects. However, there is value in assigning

exploration resources to the bundled mining camps to either grow the resources or find some small high-grade deposits that could enhance a project's NPV significantly.

First, the aforementioned economic model could be used to determine the minimum requirements for development, or to value projects that are less advanced but show potential. The later would include projects that are in the very early stages of development but might be in areas that have high potential to the corporation. An example of the later would be if geologists were successful at finding the rumoured other half of the Sullivan deposit in south-eastern British Columbia. As mentioned earlier, the Trail smelter profited greatly from the original Sullivan mine.

Second, the Chinese companies are not afraid to follow this process, as is evident by the amount of investment in the Trail catchment area. There are a couple of drivers for this. As mentioned earlier, Chinese smelter capacity is increasing in a market where concentrate supply is fixed or forecast to decrease. This investment is indicating that the Chinese companies are desperate to secure resource regardless of the economic prospect. Teck is used to dealing with rational investments but could now be confronted by irrational investors that may or may now abide by economic reason. This may also be indicative of how aggressive the Chinese companies will be to secure concentrate, which could result in a shortfall for Trail or a deterioration of smelting terms that might have a negative impact on the business unit. Tying up more projects with investment when the market is low is one way to combat this.

Finally, how does the Teck exploration group compete for capital when there is usually a bigger return when investment is made into brownfield properties i.e. expansion of Teck coal mines or the Highland Valley copper mine. In this case, is it better to partner or take a positioning the smaller companies that are more singularly focussed and have the human capital that is motivated to find and define projects that warrant investment by larger mining companies? The other issue is timing. Ideally, Teck would like to buy low and sell high. Again, the usefulness of good forecasting will help determine the low points in the market. The concern now is that the zinc market is improving, and recent valuations of properties have increased four fold in the last 9 months.[26]

[26] Alex Christopher, April 4, 2011

6.4 Enough Concentrate for Trail?

The big concern moving forward is whether there will be enough concentrate available to keep the Trail smelter operating at capacity. For Trail to maintain its 'green' status and recover urban ores, it does require a certain amount of concentrate to help carry the impurities that comes with electronic-waste. As well, with its cost structure and upward potential for metal prices there will be a positive return from operating a full zinc circuit at Trail. From the supply demand analysis, there is a significant risk that there will be inadequate concentrate supplies. This will have a very negative effect on the profitability of Trail (smelting has inherently high fixed costs - labour, facilities) and the last ton of zinc is always made at the highest profit margin (given capacity restraints).

By bundling properties, a local mine could be developed that would be large enough to ship concentrate to the market as well as supply the Trail smelter. This could increase the revenue stream from the mine at the cost of reduced life. Bundling could also result in a smaller mine but with a concentrate more suitable for Trails diverse recovery operations. By valuing the mine and smelter together, returns could be higher for the zinc business unit. Creative bundling could also create a first mover scenario for Teck that could lock down a positive development scenario. The potential of bundling might also help direct more possible drilling targets for the company to 'take a chance on'. Enhanced exploration should not just be limited to high probable projects but some projects in early states of development should be targeted as well based on potential favourable returns to Trail and the business unit.

7: Conclusion and Recommendations

Teck Resources Ltd. should alter their strategy with respect to the Zinc business unit and assign resources to developing concentrate supply. Favourable demand forecasts in combination with zinc concentrate shortage and excess refinery capacity will make operating zinc mines more profitable. Beginning the process of mine development today will allow Teck Resources to capitalize on this upswing.

Resources should be devoted for the development of an economic model that would integrate all aspects of the zinc business unit. These aspects would include estimates of price change based on different supply/demand projections and ultimate bottom line effects based on the integrated response of existing mines and the Trail smelter. The capabilities of Trail to convert the whole of the concentrate to products should be included in this model. By using this integrated model, the company can re-evaluate the status of the Pend Oreille mine. The economics of operating the mine should be in combination with the additional benefits that the Trail smelter receives from treating the concentrate and could change the operating decision for this mine. This mine would be a good source of concentrate until a different mine could be developed.

The corporate exploration and business development groups should accelerate plans for the development of a local zinc deposit. By bundling existing projects together, a potential mine plan may be developed that would produce the positive project economics that Teck requires. This strategy is likely to result in a project with multiple owners and they will have meet current Teck standards for governance and safety, health and environment. Integration with Trail should be part of the justification for the mine. Risk could be reduced by building a large enough mine to enable concentrate to be sold on the market (or if the partner is Korea Zinc, delivered to their smelter) and by becoming the primary operator and developer. Teck has proven itself as a competent operator of mines and should be a partner of choice for a fellow mining or smelting company.

The Trail smelter will be better prepared for future concentrate feeds if improvements are made to how Trail's technical support group interacts with corporate exploration, business development, and applied research groups. Tightness in the concentrate market will favour the

mines and increase the challenge to maintain current profits from Trail. The smelter is currently in the lowest quartile from an operations point of view and has a long history of smelting innovation and association with local zinc mines. It needs to build on this by securing new local sources of concentrates and planning for the new metallurgical challenges they may bring and more importantly converting the challenges to revenue streams in a timely manner.

Appendix[27]

[27]Source: Base map: © Department of Natural Resources. All rights reserved.

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