A Techno Economic Study of Mineral Sand Transportation Methods

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Abstract

Iluka Resources Limited is a leader in the global production, processing and sales of titanium minerals and zircon. Mineral sand deposits containing valuable titanium minerals and zircon are typically found in ore bodies along ancient coastlines. Costs associated with transporting mineral sands are significant compared to the overall capital and operating expenses of Iluka's mine sites. This project has been requested in an attempt to reduce transportation costs between the mining pit and concentrator.

The project is a continuation of the 2005 CEED Project by Damintha Chandrasekara, which compared conventional pumping, multistage pumping and overland conveying. This year the transport methods under consideration include:

- *Slurry Pumping*
- *Overland Conveying*
- *Trucking*

Each method will be individually optimised then compared in regards to technical aspects such as reliability and availability as well as economic issues such as capital, operating and maintenance costs of transportation methods. The outcome results in optimum transportation methods for various input factors such as tonnage rates, elevation, distance, heavy metal concentration, time period etc.

Project conclusions and recommendations will equip Iluka with the ability to identify the optimum method for transporting mineral sands between the mining pit and concentrator.

1.0 Introduction

Identifying project boundaries by examining Iluka's mining techniques was the first of many challenges in this project. Techniques varied considerably between mines to accommodate for throughput, ore composition, density, availability of equipment, haul distance etc. There is no distinct mining method employed throughout all Iluka's operations. As a result sixteen case studies were considered, based on two primary variables, throughput and distance.

Transportation throughputs of Iluka's Western Australian operations were determined from a variety of resources, including Iluka personnel and computer packages, namely Citect [1]& ProcessNet[2].

This information prompted four case studies based on throughput alone.

- Throughput Case Studies
  - 400 tonnes per hour (tph)
  - 700 tph
  - 1100 tph
  - 1400 tph

Transportation distances were also diverse because Concentrators and Mining Unit movements are not considered an option due to large downtime costs associated with dissembling, moving and reassembling. If these moves were budgeted for, it may prove a more profitable to move Concentrators and Mining Units regularly to minimise transport distances. The shortest distance was1km and the furtherest 8km. With this in mind four distances were decided upon for examination.

- Distance Case Studies
  - 2 km
  - 5 km
  - 8 km
  - 11 km

[1] Supervisory Control And Data Acquisition. A reliable control and monitoring system used to collect information and provide interface to specific equipment on Iluka sites.

[2] Computer Package which displays Iluka's real time production figures.

Process Flow Diagrams

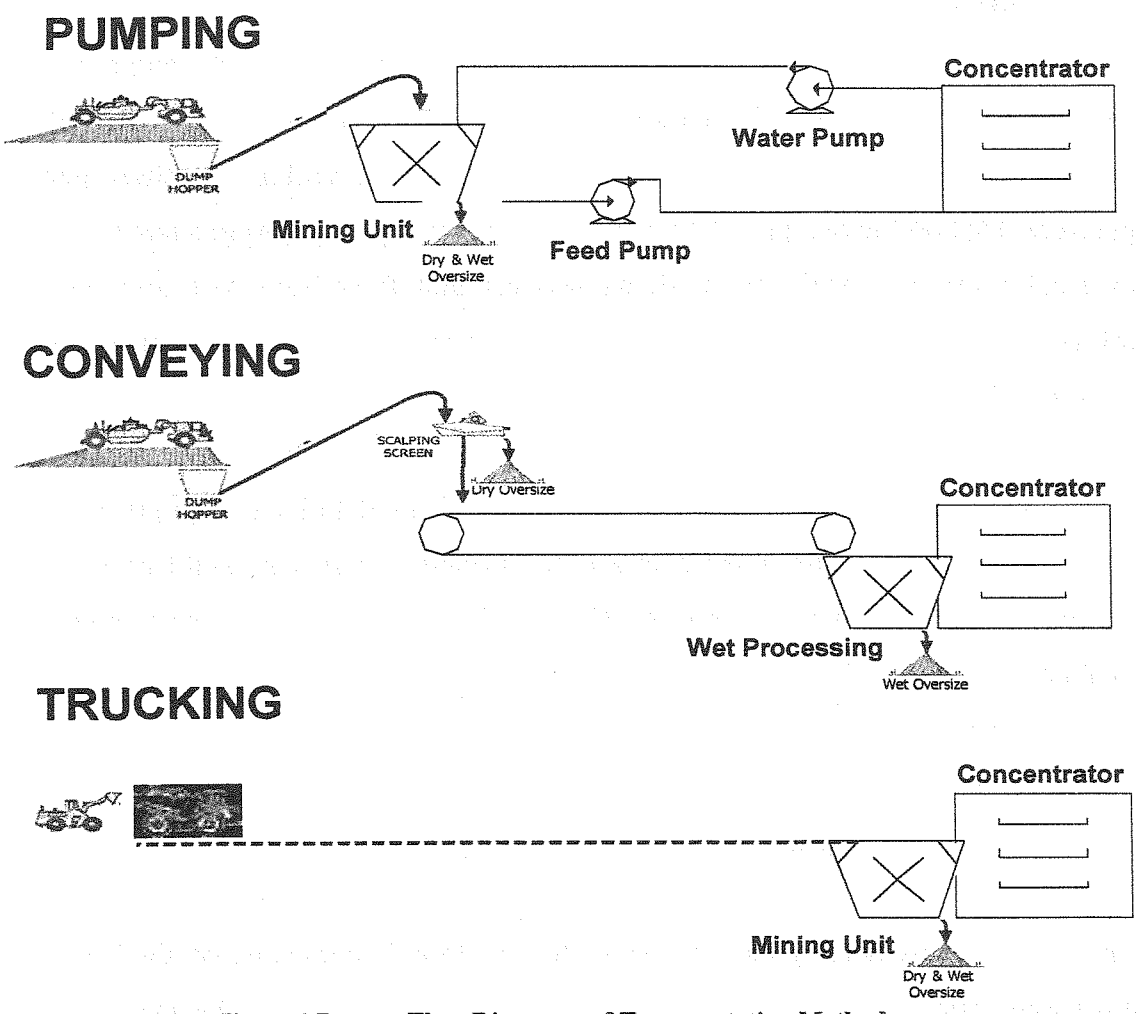

Figure 1 Process Flow Diagrams of Transportation Methods

- ***Pumping***: Self loading scrapers transport ore 1km to the in pit Mining Unit where it is assumed 10% of oversize and overburden is removed. The resulting slurry is pumped in series to the concentrator.
- ***Conveying:*** Self loading scrapers transport ore 1km to the in pit dry screening unit where it is assumed 5% of oversize and overburden is removed. The resulting ore is conveyed to the Wet screening component of the MU, located at the concentrator. It is assumed the Wet screening component removes a further 5% of oversize and overburden.
- ***Trucking:*** Loaders fill Rock trucks which transport the ore to the Mining Unit, located at the concentrator. Haul distances are specified in the boundaries, plus 1km, to accommodate for the additional 1km hauled by the scrapers for both pumping and conveying. Oversize is returned to the pit on return runs, as necessary.

2.0 METHODS AND PROCEDURES

Each transport method is analysed technically with appropriate engineering calculations to ensure suitable equipment was sourced. Pumping required detailed hand calculations to determine slurry composition, limiting settling velocities, pump pressure, friction factors, pipe diameters etc. Conveying details were sourced by an external contractor, while truck sizing was calculated by hand with appropriate information from Caterpillar.[3] These results were refined by a trucking computer package, FPC[4].

After equipment sizing and selection, sourcing and availability of equipment was investigated. All quotations and contracts for pumping, conveying and trucking are accurate and may be found in Appendix C of the Thesis Paper. Costs of each transport method were broken down into the following categories:

- Capital & Installation
- Operation (p.a.)
- Maintenance (p.a.)

The cost of implementing each transportation method is compared on the basis of discounted cash flows. The discount rate used is Iluka's Weighted Average Cost of Capital (WACC) which is used internally throughout Iluka to compare the economic feasibility of future projects. Comparative costs of transport methods were calculated using discounted cash flow methodology, expressed as a Net Present Cost (NPC) over a time period of 10 years. Of the sixteen cases examined the optimum transport method returned the most favourable NPC.

3.0 RESULTS AND DISCUSSION

The following four graphs outline the NPC's for each distance examined. The NPC is on the vertical axis with throughput on the horizontal axis. The least negative the NPC outlines the more favourable transportation method. As can be seen in ***Figures 2 - 5*** trucking is a by far the more expensive alternative, especially over long distances and higher throughputs.

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[3] Caterpillar Inc. 2003, *Caterpillar Performance Handbook Edition 31*. CAT, USA.

[4] Fleet Production & Cost Analysis. Version 3.05B. Copyright Caterpillar Inc. 2005

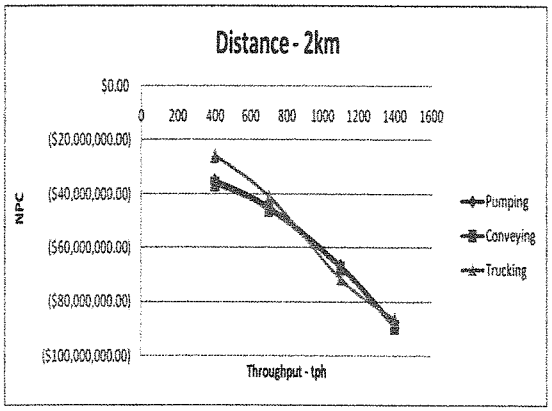

Figure 2 - NPC Comparison 2km

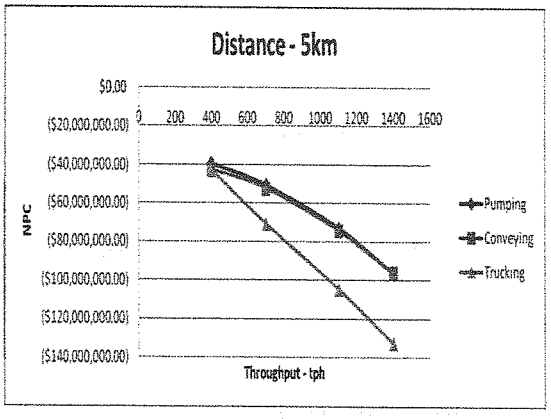

Figure 3 - NPC Comparison 5km

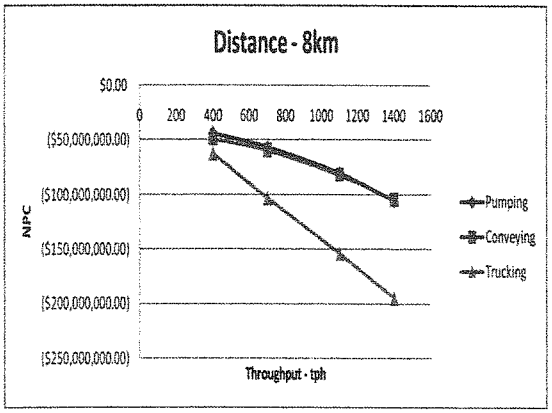

Figure 4 - NPC Comparison 8km

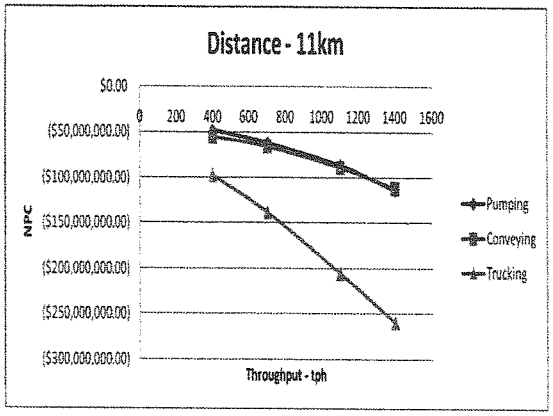

Figure 5 - NPC Comparison 11km

4.0 CONCLUSION

Extensive study of results clearly identified pumping as being the optimum transportation method, which indicates Iluka is employing the correct method for transportation of mineral sands between the Mining Unit and Concentrator.

After discussions with Iluka employees it became apparent that the mobility of slurry pumping is worth the additional costs over long distances and at 1400tph. A definitive study in regards to mobility and relocation costs may need to be carried out to determine if slurry pumping is in fact the optimum transportation method at 1400tph.

Also, regardless of transport method employed between the Mining Unit and Concentrator, waste from the concentrator has to be slurry pumped to tailing dams.

Employing an additional transport method may break up the current skilled and efficient maintenance workforce.

Major recommendations include:

- A detailed sensitivity analysis of transport route gradients.
- A detailed study into Iluka's moving frequency of Mining Units and Concentrators.

6.0 REFERENCES

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