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Dragline or Truck/Shovel?

Some Technical and Business Considerations

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DRAGLINE AND/OR TRUCK / SHOVEL ASSIST:

SOME TECHNICAL AND BUSINESS CONSIDERATIONS

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ABSTRACT

Truck/shovel fleets form the backbone of the Australian open cut mining industry. Where applicable, draglines are often applied to open cut coal mines. Draglines are the lowest cost waste removal mining method (in the right deposit) but are less flexible and have a higher capital cost. Truck/shovel fleets on the other hand are far more flexible, lower in capital but have higher operating costs.

Shareholders of mines typically want an operation with low capital and low cash operating cost, but also want to maximise value in discounted cash flow terms with known or manageable risk. In this relentless drive to maximise profit to shareholders, the deployment of draglines and truck/shovel fleets can be varied so that competitiveness (lower costs) can be traded off with maximising profit (more tonnes but higher cost). Given the large revenue fluctuations over recent years, which is the best option to plan for?

By modelling an “Example Mine”, the use of a dragline and truck/shovel fleet in a typical Australian deposit is examined to illustrate this trade off. This is then compared to recent history in coal price and exchange rate variations to illustrate the different risk profiles. The outcomes show wide ranging results, whereby the preferred operating system is dependent on specific deposit characteristics, shareholder requirements and corporate guidelines.

Given the recent trend towards utilising mining contractors, there are increased opportunities for mines to have a more flexible mine plan, where the dragline and truck/shovel deployment can be varied to suit market conditions.

INTRODUCTION

This paper focuses on the application of truck / shovel systems to augment conventional dragline operations. Some general topic guidelines offered by UNSW included:

- the theme had to be specific to the Australian open cut coal industry
- there will be a wide audience including undergraduates, junior and senior graduates, mine owners and bankers, and
- the paper needed to cover basics as well as some more advanced and detailed commercial and operating aspects.

Some key developments in the open cut coal mining industry over the previous 30 years as they relate to this paper include:

- mines are operating at significantly higher annual tonnages (from < 5 Mtpa then versus +10 Mtpa now)
- there has been consolidation of ownership
- there is a much wider use of contractors
- mines are deeper, more complex and operate at higher strip ratios

- the mining equipment is larger
- the number of operators is less (conversely, productivity is higher), and
- hydraulic excavators as the primary excavator for a truck/shovel fleet are more common now than electric shovels, which were the dominant machine in the 1970's.

Before going further it is timely to introduce "business considerations" associated with draglines and truck/shovel systems. Shareholders expect a return on their investment; to achieve this return, typical guidelines are:

- minimise capital
- identify and manage risk
- minimise cash cost (especially relative to competitors)
- maximise value from the resource, and
- comply with statutory, safety and environmental standards.

None of the guidelines are unreasonable, but unfortunately they can be conflicting. For example, draglines are low cash costs, but are high capital. Truck/shovel are lower capital, but higher cost! Contractors reduce the capital requirement and can reduce risk; but a margin and capital recovery factor needs to be factored into the rates, which increase cost. How do planners recommend which is best?

The aim of the paper is to therefore share some of these experiences and to present a line of logic leading to this dilemma facing shareholders and planners, in coming up with a mine plan which meets the shareholder's sometimes-conflicting guidelines. That is, wanting to maximise value at low cost and risk and with minimal capital. The aim is not to reach a precise conclusion but to highlight the important link between technical, operating and business issues, which need to be quantified and understood in any mine plan so that informed business decisions can be made.

The approach adopted for this paper is to begin with a broad overview of the Australian open cut industry and to then describe the basic features of dragline and truck/shovel mining systems. The term "truck/shovel" does not just refer to electric face shovels but also includes hydraulic excavators. After some of the physical and cost characteristics of draglines and truck/shovel operations are understood, some of the long-term business options confronting the Australian open cut industry are introduced. That is, in the relentless drive to maximise profit to shareholders, the deployment of draglines and truck/shovel can be varied so that competitiveness (lower costs) can be traded off with maximising profit (more tonnes but higher cost) by varying the dragline operating horizon and consequently changing the proportion of truck/shovel material.

The impact of using a dragline differently in the same deposit is quantified by creating an "Example Mine" and then scheduling the dragline and truck/shovel fleet differently through the same deposit, and finally comparing outcomes. Whilst theoretical, the issues are relevant as many mines have deposits similar to the example in that they are becoming deeper and more expensive.

OVERVIEW OF THE AUSTRALIAN OPEN CUT COAL MINING INDUSTRY

The objective in this section is to provide a brief history of the Australian open cut coal industry and then to take a quick snapshot of the industry as it stands today.

Large-scale open cut strip mining for coal commenced in Australia in the mid 1960s. At that time it was a fledgling industry and most of the technology and equipment was imported. Large walking draglines were introduced as the principal overburden stripping units, and in many operations, remain so today. However as the seams have become deeper and the complexity of the coal and waste increased, secondary stripping equipment such as truck/shovel, dozers, and techniques such as throw blasting, have been introduced.

Australian strip mines operate over a range of individual pit and overall working lengths. The working length can be up to 70 km made of many separate pits of 0.5 km to 2 km long. There is a tendency for shorter working pit lengths in New South Wales (NSW) operations compared to Queensland (Qld).

In broad terms mines can be classified by their primary method of waste removal such as draglines only, draglines with pre-strip or truck/shovel only. The following paragraphs briefly describe the main features of each method.

Draglines
Draglines are the lowest cost waste removal equipment but are generally restricted to:

- large deposits to ensure adequate strip length and sufficient reserves to justify the capital expenditure
- gently dipping deposits, due to spoil instability on steep dips
- simple geology and gentle terrain to ensure minimal changes in overburden thickness along a strip, and
- shallow deposits, as draglines usually excavate a maximum of 60-70m of overburden due to dump reach and height limitations.

Draglines work in strips, which are typically 50–90 m wide and several kilometres long. Overburden is excavated by the dragline and dumped on the surface for the initial strip (box cut) and subsequently in adjacent mined out strips. Strips are generally aligned along strike with each subsequent strip down dip from the previous strip. The dragline starts at one end of the strip and advances along the strip to the other end. At the completion of each strip the dragline relocates (dead head) to start of the strip and commences on the next strip. Access ramps are left through the overburden dump for access for coal mining.

The key dragline planning parameters are dump height, dig depth and dump radius. As overburden depths increase, various benching techniques are used to ensure that the dragline can place overburden in the required dump profile. These benches are then rehandled by the dragline as it moves along the strip.

Draglines are often supplemented by throw blasting and/or dozer assistance to increase overburden removal capacity.

Dragline with Pre-Strip
In this mining method, the overburden in excess of the dragline dig depth (termed pre-strip) is removed by other mining equipment. The pre-strip material is excavated from future mining

strips and dumped onto previous dragline dumps. The remaining overburden is at the optimal dragline operating depth for subsequent excavation by a dragline.

The main pre-stripping equipment used is truck/shovel and shovel/crusher/conveyor. Trucks haul overburden around or across the operating dragline strip to previous dragline dumps. Truck/shovel equipment provides the flexibility for easy relocation to isolated pre-strip areas, for example, if pre-strip is only needed where a strip crosses a ridge. Truck/shovel equipment can also be easily increased to match the steadily increasing requirements for pre-strip removal.

Shovel/crusher/conveyor is used for larger pre-strip requirements. The shovel excavates overburden, which is dumped into a crusher to reduce the material to a suitable size for conveying. A series of conveyors transport the overburden along the strip, then across the strip to a stacker located on the dragline dumps. The high capital cost and inflexibility of shovel/crusher/conveyor dictates that this system is only likely to be justified for large mines.

Some other pre-stripping equipment that has been tried at Australian mines includes bucket wheel excavator and a dragline loading into a mobile truck-loading hopper, although neither of these systems are now operating.

Truck/shovel
Truck shovel methods are inherently more flexible than dragline methods, which make truck/shovel methods better suited in the following applications:

- geologically complex deposits with resultant irregular pit shapes, which could not be efficiently mined by a dragline
- steeply dipping deposits, where the equipment could not operate on the seam roof and floor. Overburden is initially dumped ex-pit and then in-pit when sufficient dump room is available. The pit is excavated as a series of horizontal benches (terraces) and coal and waste are exposed on every bench. Each bench extends from the floor of the lowest seam to the down dip economic pit limit.
- small deposits, which do not justify the capital expenditure of a dragline.

Table 1 shows a comparison of a dragline mining system and a truck/shovel waste system in terms of capital and operating costs. The dragline shows a definite cash cost advantage but has a much higher capital cost compared to the shovel and truck system. The tabulation is based on the following assumptions:

- the dragline is a 80 bcm bucket and assumes dozer assist and throw blast,
- the truck/shovel cost in this example is a hydraulic excavator loading 220 tonne trucks in 4 passes,
- both comparisons include allowances for drill and blast,
- both comparisons include support equipment such as a grader for the truck/shovel and a dozer for the dragline, and
- the "capital cost" is based on a commercial leasing arrangement .

Table 1
Draglines vs Truck/Shovel

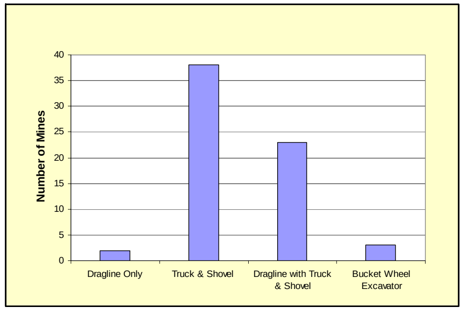
	Units	Dragline	Truck/Shovel
Nominal Prime Capacity	Mbcm	26	11
Capital Cost	$A millions	80	34
Cash Operating Cost	$A/bcm	0.80	1.60
Capital and operating cost	$A/bcm	1.30	2.50

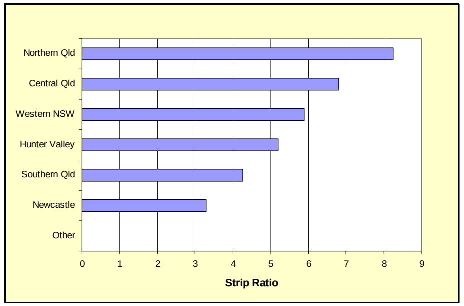
As part of a recent study by MineConsult, a survey of over 60 Australian open cut coal mines was undertaken with the results, shown in **Graphs 1** to **3**, showing the significance of dragline and truck / shovel systems in the overall industry and the trends with respect to strip ratio and size of operation.

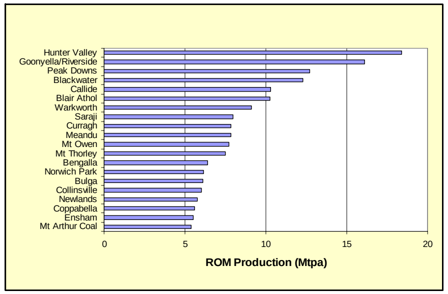
Graph 1 highlights how few mines use dragline alone. This was not the case 30 years ago, especially in central Queensland. Secondly, truck/shovel mines outnumber "dragline with truck/shovel mines". Thirdly, with over 25 mines having draglines and some mines having more than 4 machines on the one property, this shows how many draglines there are operating on the east coast of Australia (over 50 machines).

Graph 2 shows strip ratio and hence the quantity of waste moved. It is this aspect of costing that this paper will focus on. **Graph 3** shows coal production for the 20 largest producers in Australia.

Graphs 1, 2 & 3
2003 Australian Open Cut Coal Mining -Overview







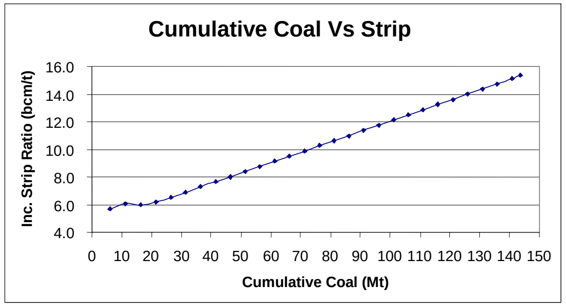
EXAMPLE MINE

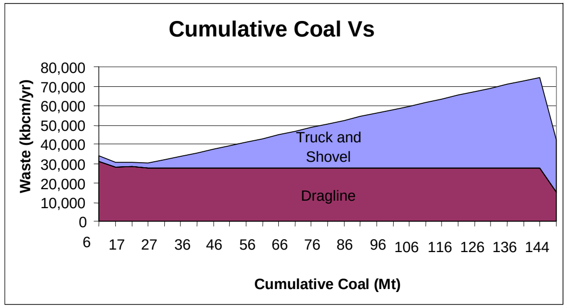
To allow a realistic set of comparisons to be made the following “Example Mine” was created, based on the following assumptions:

1. It is an open cut coal mine with several seams, a moderate dip, and a cumulative coal thickness of 8 metres separated by several thin partings.
2. The mine has been operating for some years and the depth of the deposit is now 60 meters but at the final lease limit the depth is 180 metres.
3. The reserves total approximately 150 million tonnes
4. The strip ratio is now 6 bcm/ROM tonne but will be 15 bcm/ ROM tonne at the end of the mine life.
5. The mine already owns a 90 cubic metre dragline as the principal waste removal machine.
6. The mining method uses throw blast, doze assist and when the depth is greater than 65 metres the additional material is mined by truck/shovel pre-strip.
7. The coal is mined by front end loader loading rear dump trucks
8. The coal is sold unwashed at the mine mouth and net of marketing cost, royalties and any transport cost has a revenue ranging from $A 25 to $A 30 per tonne.

Graph 4 and 5 show the trend of strip ratio and waste versus cumulative tonnes. The main conclusion is that as the mine continues over its life the amount of waste required to maintain production increases. Further, the proportion of pre-strip increases.

Graphs 4 & 5
Example Mine Physicals





OPERATING ALTERNATIVES

The objective in this part of the paper is to give a general description of a dragline operating technique which could be used for the Example Mine and then to further develop three alternative digging methods based on the same dragline supported by truck/shovel pre-strip. The equipment assumptions are as follows:

- single dragline with 90 cubic metre bucket
- dragline can dig to 65 metres depth and move nominally 26 million bcm per year
- pre-strip is by contract truck/shovel methods let out to mining contractors, and
- the pre-strip contractor has production flexibility in that he can vary the annual capacity to meet the needs of the mine.

Figure 1 illustrates three possible design alternatives to mine the deposit utilising the same dragline specification. The “**Base Case**” has the dragline digging to its physical limits of 65 metres assisted by truck/shovel pre-strip. The first alternative option has the dragline horizon reduced from the 65 metres to 45 metres and is labelled “**Fast – Shallow**”. The features of this design are:

- the productivity is higher as the hoisting is less and cycles are faster
- the rehandle is less
- the rate of coal uncovered is faster because of the combination of less prime, a lower rehandle and higher productivity
- the pre-strip requirement is higher, and
- the truck/shovel pre-strip task is greater (and therefore the cost is higher) as there are more benches and the elevation is higher.

The **“Deep - Slow”** option has a pullback step, which is when the dragline moves to the spoil side and rehandles some of the spoil material to create more space for prime material. This slows down the dragline but the benefit is that the dragline moves a greater percentage of prime waste and generates less truck/shovel pre-strip. The overall aim is to lower the total waste removal cost.

Figure 2 (provided by Ross Haupt Mining Services) shows step by step the sequence in the Deep – Slow, pullback method with a brief description of each step. The other two methods have similarities but are not repeated step by step as the aim is to overview the method rather than focusing on intimate detail.

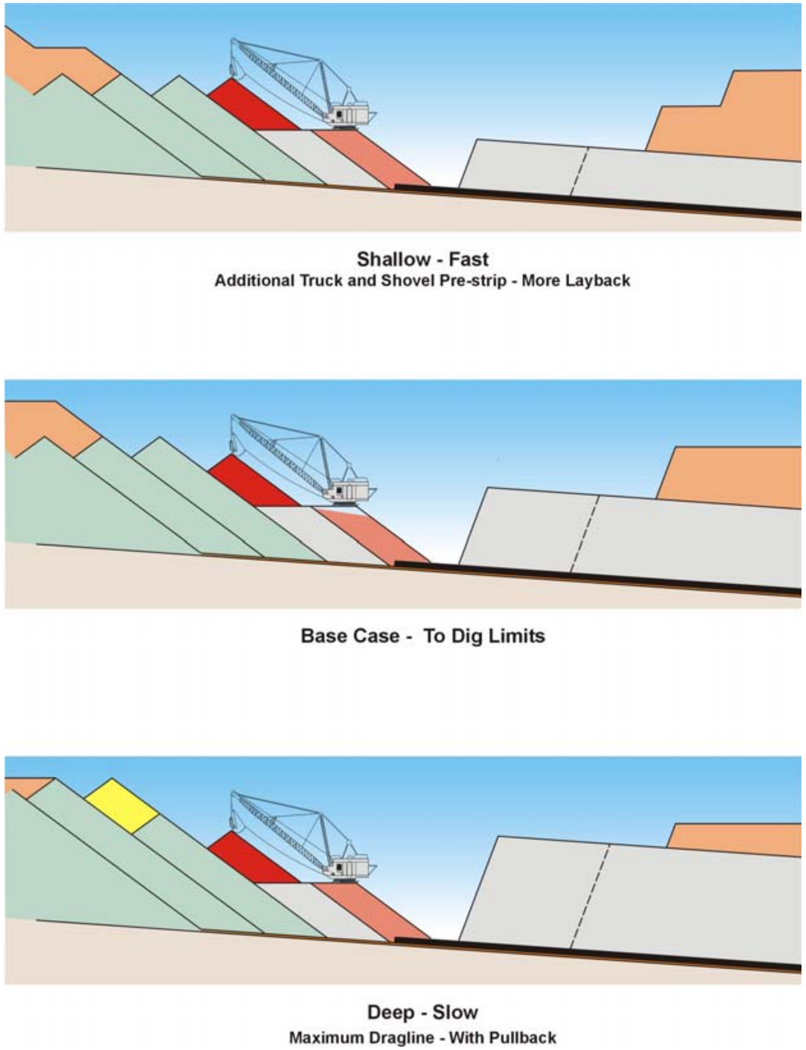


Figure 1
Three Alternative Dig Techniques

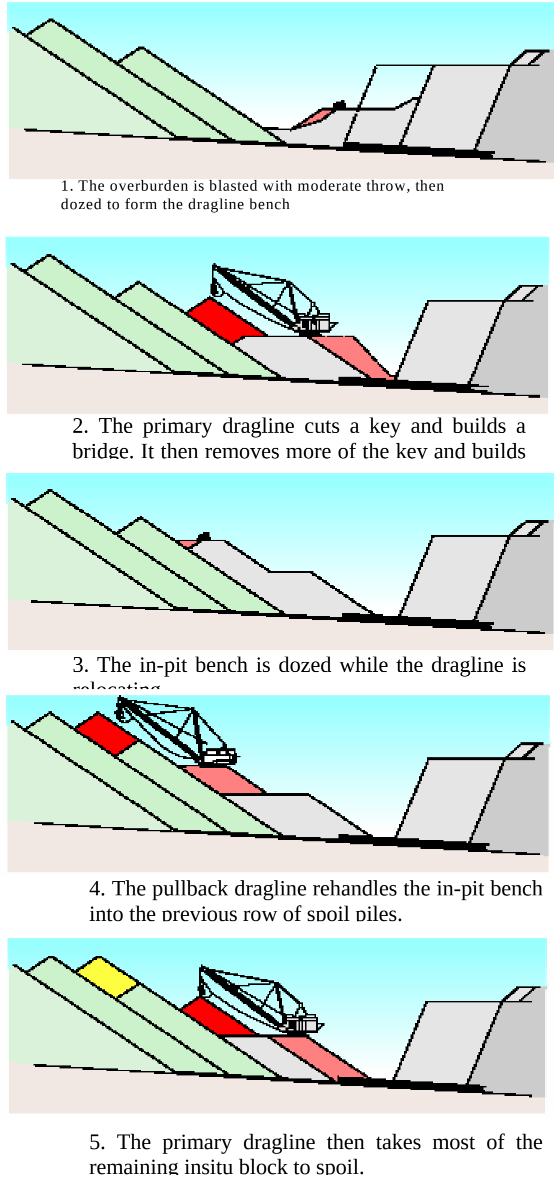


Figure 2
Dragline Operating Technique Including Pullback

WHICH IS THE BEST OPTION?

To quantify the impact of the three different operating techniques, a three step modelling process was used which is briefly described in the following paragraphs.

Firstly, a mining block database was created and input to a "schedular" which allowed the relationship of coal and waste to be calculated over time for the different dragline mining methods. For example, for the ***Fast / Shallow*** method, the proportion of dragline material in each coal block was reduced, the ITF lowered and therefore the proportion of truck/shovel pre-strip increased. As the dragline capacity is fixed, then the amount of coal uncovered and the amount of pre-strip is higher. Conversely, for the ***Deep / Slow*** method, the proportion of dragline material in each coal block is increased, the ITF is higher and therefore the proportion of truck/shovel pre-strip is less. In this case the amount of coal uncovered and the amount of pre-strip is lower. Key outputs of this step were coal, dragline, dozing, drill and blast and truck/shovel pre-strip quantities.

The second step is to determine the mining equipment needed to achieve the schedule. This includes the type of equipment (such as dragline, excavators or front end loaders), the size and number of each type and the productivity and work hours associated with the fleet of equipment. The key output of this second step is a fleet of equipment and the number of hours the equipment is digging or producing.

The third and final step is to determine the "cost" of mining the block of coal and delivering it to the market or sales point in an economic model. The economic model ties together production, equipment, workforce and builds up capital and operating costs. After revenue is calculated, the after tax net cash flow can then be discounted and a net present value determined.

The three draglines scenarios have been run through this process and **Table 2** and **Graphs 6 to 10** show the Coal and Waste production schedules for each option, operating costs and cumulative net present value at different selling prices. The coal production varies significantly as follows:

- the deep-slow option produces only 2.5 Mtpa
- the Base Case produces 5 Mtpa, and
- the fast – shallow option produces nearly 9 Mtpa.

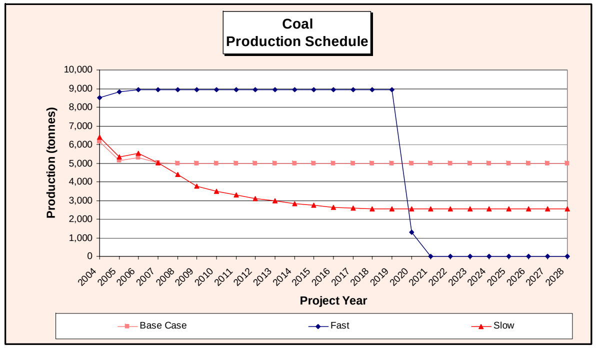
At the 9 Mtpa rate the production schedule only last 16 years whereas at the lower rates the mine lasts for +25 years.

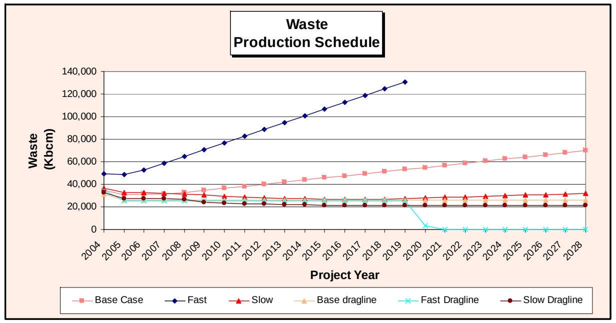
The waste graphs also show significant differences. The prime waste removed by the draglines is relatively constant at approximately 25 Mbcm per year. For the slow case the difference between the total and the dragline is not significant.

Table 2
Option Results

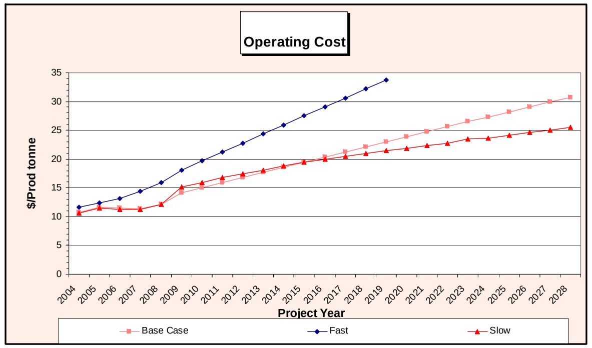
Item	Units	Shallow Fast (45m)	Base Case (65m)	Deep Slow (90m)
Average production	Mtpa	9.0	5.0	2.5
Percent Dragline	%	44	60	91
Percent Truck/shovel	%	64	40	9
Average Operating Cost	$A/tonne	24	20	18
NPV @ $30 selling price	$millions	425	437	375
NPV @ $25 selling price	$millions	130	251	233

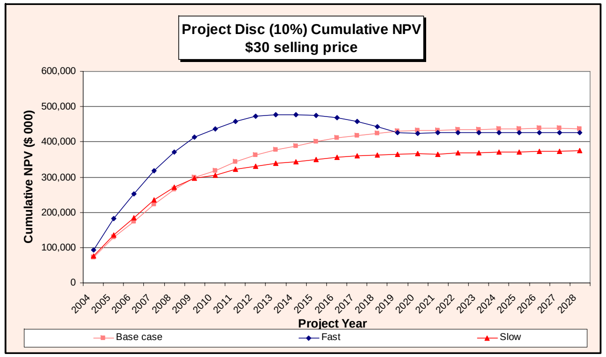
Graph 6& 7
Coal and Waste Production Schedules

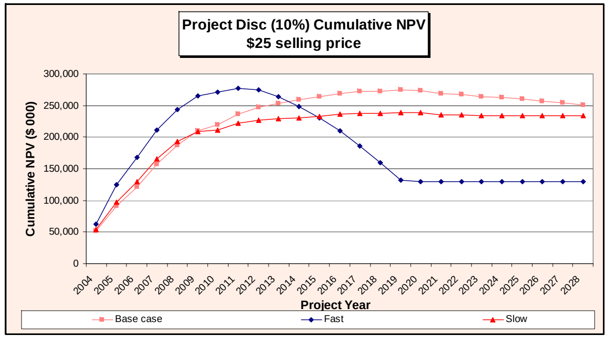




Graph 8, 9 &10
Operating Cost
NPV at $A 30/ product t
NPV at $A 25/ product t







SUMMARY AND CONCLUSIONS

Shareholders of coal mines typically want an operation with low capital and low cash operating costs; but also want to maximise value in discounted cash flow terms with known risk. Draglines typically can offer a low cost waste removal mining method but are less flexible and have a higher capital cost. Truck/shovel fleets on the other hand are far more flexible with lower capital but generally higher unit costs.

The deployment of draglines and truck/shovel fleets can be varied so that competitiveness (lower costs) can be traded off with maximising profit (more tonnes but higher cost) by varying, for example, the dig horizon or the rate the dragline uncovers coal.

By modelling an "Example Mine", the use of a dragline and truck/shovel fleet in a typical Australian deposit is examined to illustrate this trade off, between mining faster (more tonnes at lower margin) versus slower (less tonnes at higher margin). The outcomes show a wide range of results. The correct answer is dependent on specific deposit characteristics, shareholder requirements and corporate guidelines.

Given the recent trend towards utilising mining contractors, there are increased opportunities for mines to have a more flexible mine plan, where the dragline and truck/shovel deployment can be varied to suit market conditions.