Crushing & Conveying

A New Mining Technique for the Hunter

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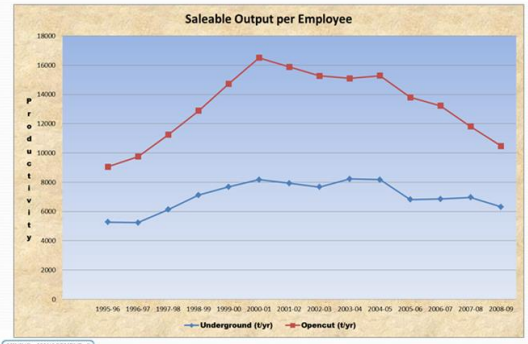
Issues Facing Open Cut Mining in the Hunter

- Reducing productivity
- Deeper operations
- Environmental impacts
- Competing land use

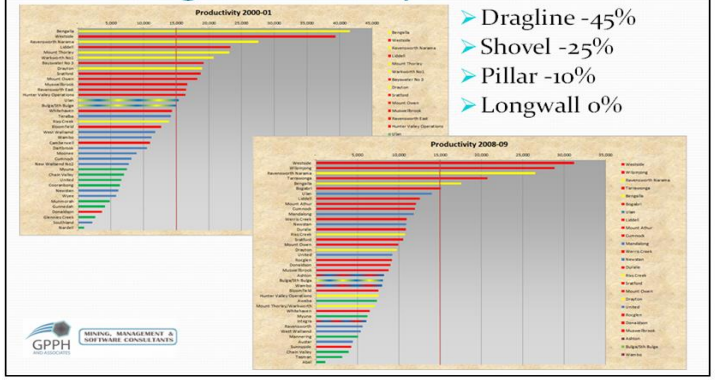
Four issues are relevant to future mining method selection.

Reducing Productivity



This is a plot of productivity per employee for Hunter Valley mines from 1995 to 2009. Productivity gains in open cut mines by the end of the 20th century have largely been lost.

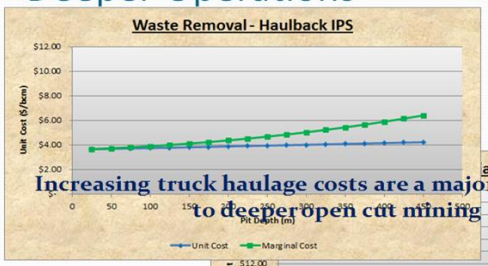
Reducing Productivity



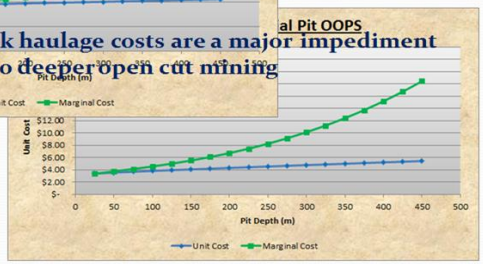
- Dragline -45%
- Shovel -25%
- Pillar -10%
- Longwall 0%

This shows productivity by mine with Dragline operations in yellow, shovel/truck in red, pillar mining in green and longwall in blue in 2000.
A comparison chart is given for 2008, with the red line indicating 15,000 t/man-yr.
Over 8 yr dragline operation productivities have dropped by 45%, shovel/truck operations by 25%, while underground productivities have only fallen slightly.

Deeper Operations



Marginal costs for deep mining with in-pit dumping are also high



Increasing truck haulage costs are a major impediment to deeper open cut mining

These charts show the average and marginal costs of waste removal using shovel/truck methods.
The first chart shows the very high cost of developing the void.
But costs also increase with depth for in-pit dumping.
The conclusion is that truck haulage costs are a major impost for deeper mines.

Environmental Impacts

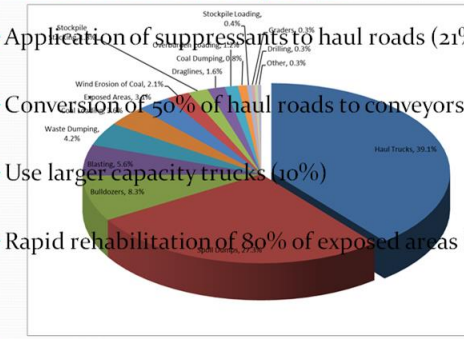
The key environmental impacts are:

- **Dust** – coal mining is 34% of -10µm emissions for GMR
- **Noise** – a major concern for nearby residents
- **Visibility** – perceived business impacts and light pollution
- **Aquifer Interference** – impacts on irrigation & quality

GMR is Greater Metropolitan Region of Wollongong, Sydney and Newcastle, including the Hunter Valley.

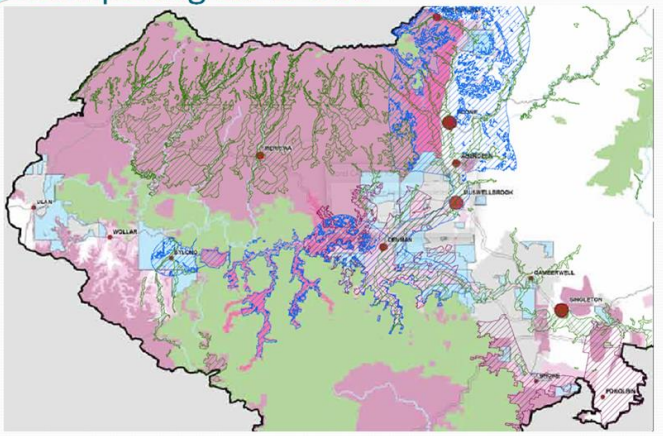
Environmental Impacts

- Application of suppressants to haul roads (21%)
- Conversion of 50% of haul roads to conveyors (20%)
- Use larger capacity trucks (10%)
- Rapid rehabilitation of 80% of exposed areas (20%)



Katestone Environmental studied dust sources in the Hunter and found haul trucks and exposed spoil dumps to be the primary sources of dust.
Four of their key recommendations and potential reductions in overall dust make are shown.

Competing Land Use



Existing coal leases are in grey; existing exploration licences are in light blue; high potential opencut exploration is light pink around Broke, Denman and Wollan; potential opencut is bright pink west of Scone.
The Viticulture group Strategic Agricultural Land (maroon)
The Equine group SAL (dark blue)
Biophysical SAL (green)
An existing lease is a valuable commodity.

Possible Solutions

- Underground Mining
- Crushing & Conveying of Waste
- Other Solutions (automation, dusticides, etc.)

Other solutions can also apply to the other two mining technique solutions and will not be discussed.

Underground Mining

Advantages	Disadvantages
Reduced dust emissions.	Larger areal extent.
Reduced noise emissions.	Subsidence may be an issue.
Reduced visibility impact.	Inflexible requiring strict geological conditions.
Improving technology & productivity.	Poor overall resource recovery.
Ability to select a target seam.	Marketing & blending constraints.

Undoubtedly, underground mining will increase as a proportion of total mining in the Hunter. It is not universally applicable and may not be feasible or desirable in all areas.

Crushing & Conveying Systems

Mobile and semi-mobile crushers fed by shovels or trucks, respectively.
Beltwagon, bridge conveyor or relocatable conveyors to provide flexibility at the mining face.
Shiftable conveyors to allow for intermittent dig or dump face relocation.
Conveyors form the heart of the system.
Tripper and spreader to allow waste dumping.

Limitations

- High initial capital outlay.
  - Generally neutral with truck replacements.
- Reduced flexibility compared with truck & shovel.
  - Fully mobile systems have poorer flexibility.
    - Shiftable or relocatable conveyors.
    - Horizontal benches and constrained geometry.
    - Buffered blasting to protect conveyors.
    - Greater technical risk due to complexity.
  - Relocation of semi-mobile crushers.
    - Rapid advance rate of mining faces.
    - Need to advance multiple benches.

Capex is less than double a similar shovel/truck system including ancillary equipment.
(System Capex ~$150M for a system capable of 23Mbcm/yr excluding loaders & trucks)

Advantages

- Reduce operating costs.
  - Semi-mobile IPCC equal to shovel + 6 trucks.
- Reduce dust & noise emissions.
  - Sprays, covers, belt cleaners, dust suppression.
  - -25dBA noise suppression possible.
- Improve visual acuity.
  - Out of pit spoil can be dumped remotely.
  - Dumps created to final height by spreader allowing rapid rehabilitation.

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Wherever hauls require more than six trucks per shovel an IPCC will give an operating cost advantage.
Dust and noise can be significantly reduced with attention to mine design and equipment specification.
Reduced haulage costs and method of dump construction favour reduction in visual impacts with careful design and equipment selection.

Key Drivers for a Deep Open Cut Mine Plan

- Maximum haul distance around 1.5km.
- Dump pockets relocated every 10 to 20 years.
- Upper benches conveyed – lower benches in-pit hauls.
- Mobile equipment operates below topography.
- Surface equipment shielded from neighbours.
- Dumps created to allow rapid rehabilitation.
- Working faces as steep as possible.

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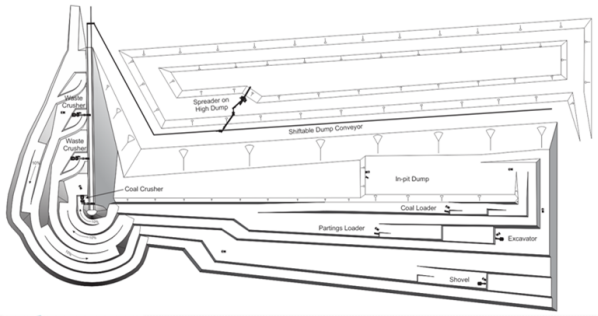
Haul distance is to maintain a three truck haul fleet per shovel.
Re-use of dump pockets over a long period significantly reduces ongoing earthworks capital requirements and reduces delays in crusher relocation.
Longer hauls and higher hoisting of waste is best performed by conveyor. This also assists with reduction in environmental impacts.
Below topo operation assists with visual, noise and dust reduction.
Smaller bunds are required to shield conveyor systems and equipment.
Spreaders can allow rapid rehabilitation to reduce exposed dump areas.
Steep faces reduce the mine footprint, which is more feasible with a deep operation.

Example Mine Design



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Initial conveyor installation shown at left.
Advancing pit (2km long) shown at right, with some truck haulage directly to a short dump via the endwall.
Truck hauls for upper benches largely horizontal to crusher stations. Elevation of waste using conveyors.
Lower benches mined as truck and shovel operation using cross-pit haulage bridges or endwall roads to in-pit dumps. Hauls are short and flat.
Spreader dumps 2 to 4 lifts above in-pit truck dumps after out of pit spoil dump is completed. Rehabilitation can take place immediately behind the spreader dump since this is constructed to the final landform.
Mining progresses around the conveyor ramp. The pit as shown is at a depth of 200m, but this pit progressed to a depth of +300m over a 20 year mine life without relocation of dump pockets.

Conclusion

- Changing conditions are forcing open cut mining deeper.
- New technology required to:
  - Allow continued economic operations.
  - Addresses environmental impacts.
- Underground mining is a possible solution:
  - Poor resource recovery.
  - Not universally applicable.
- Semi-mobile IPCC with conventional shovel/truck:
  - Low cost solution.
  - Better environmental outcomes.
  - Little technological risk.
  - Requires an innovative mine design.

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