Appendix 1

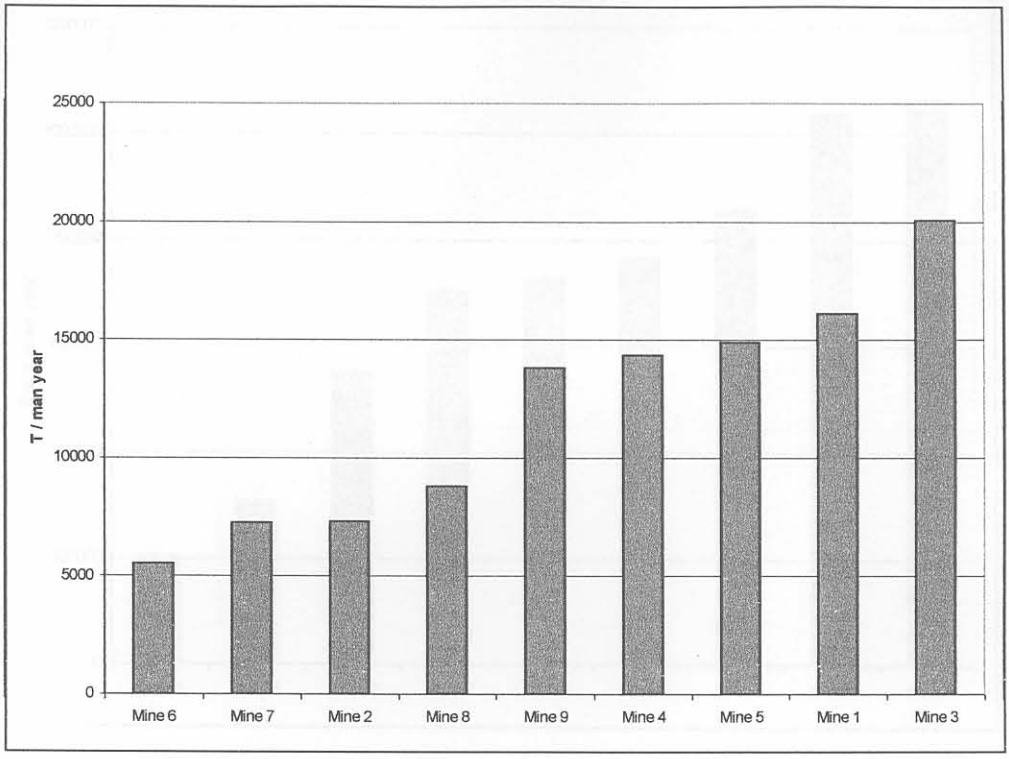


Figure 1: South African ROM tons per man-year, excluding contractors

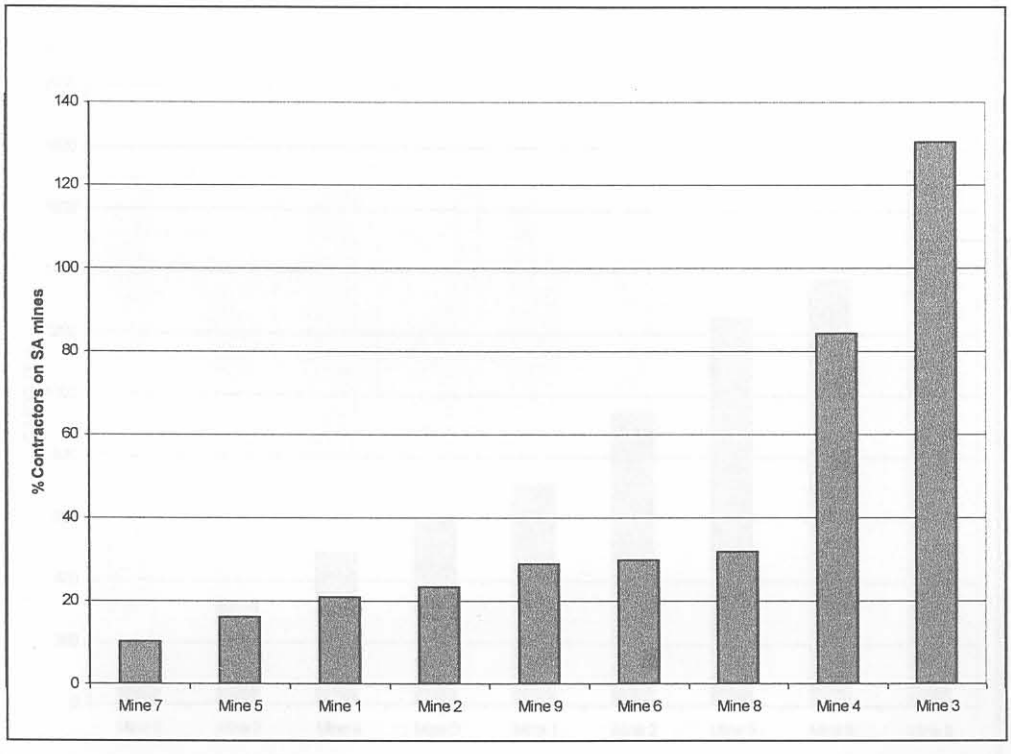


Figure 2: Contractors as a % of mine employees working on South African mines

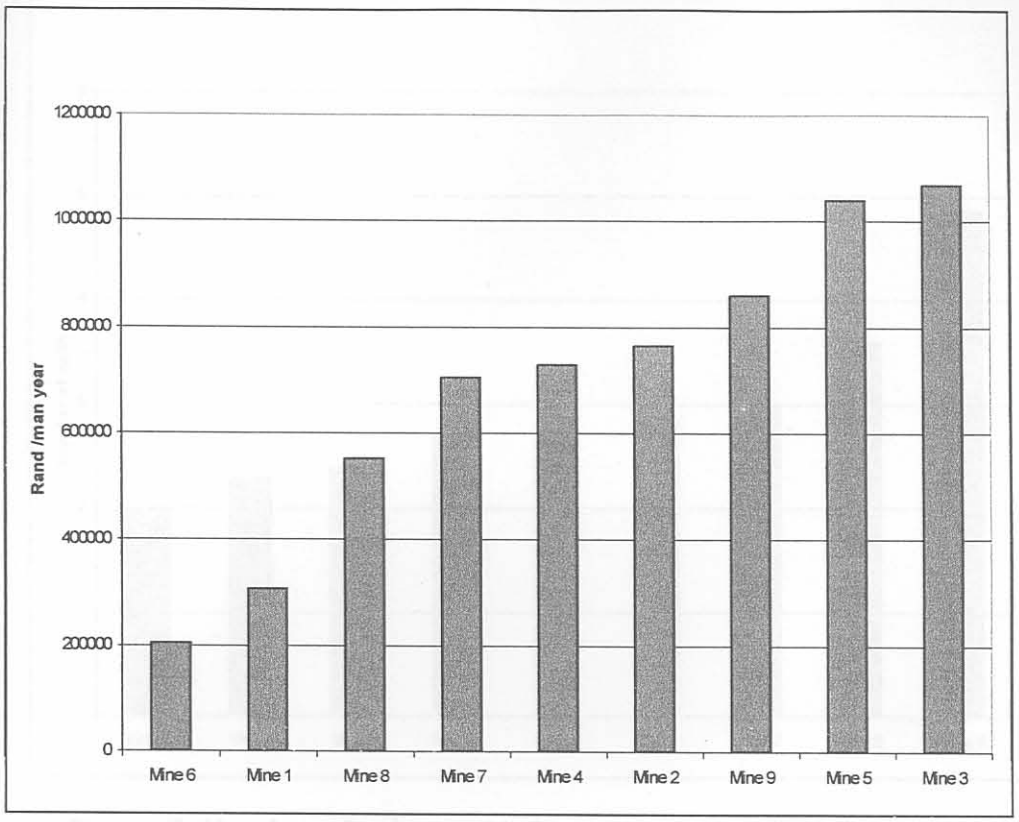


Figure 3: South African mining CAPEX per mine employee, including contractors

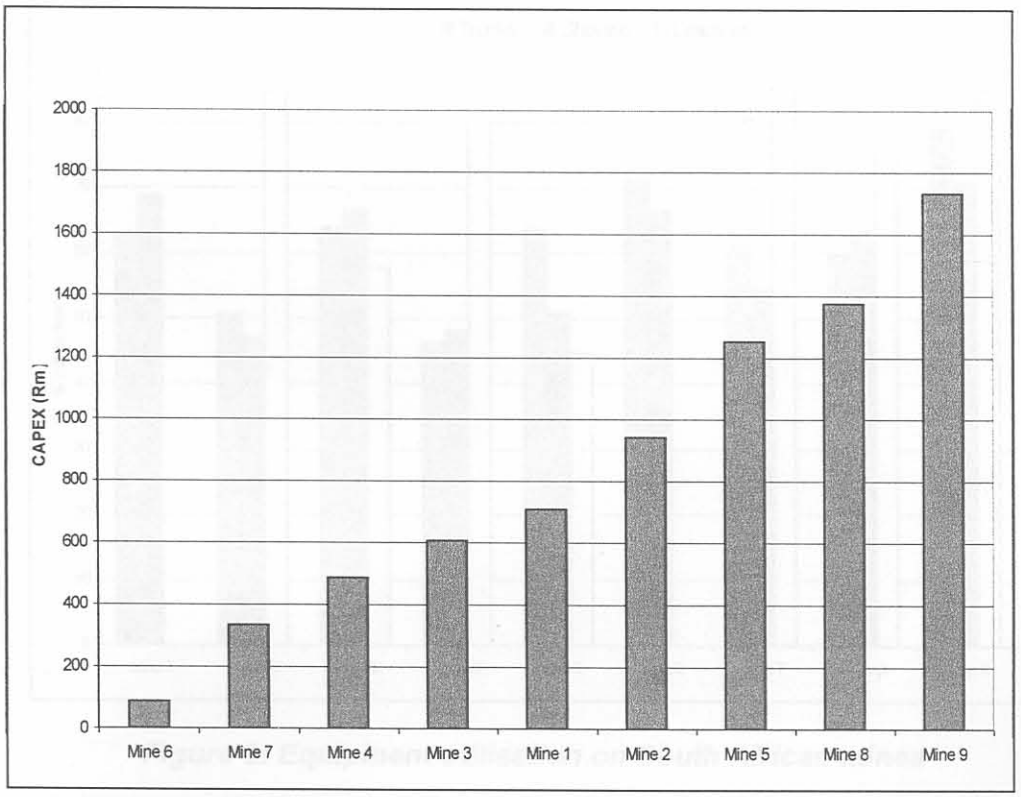


Figure 4: Capital invested on South African mines

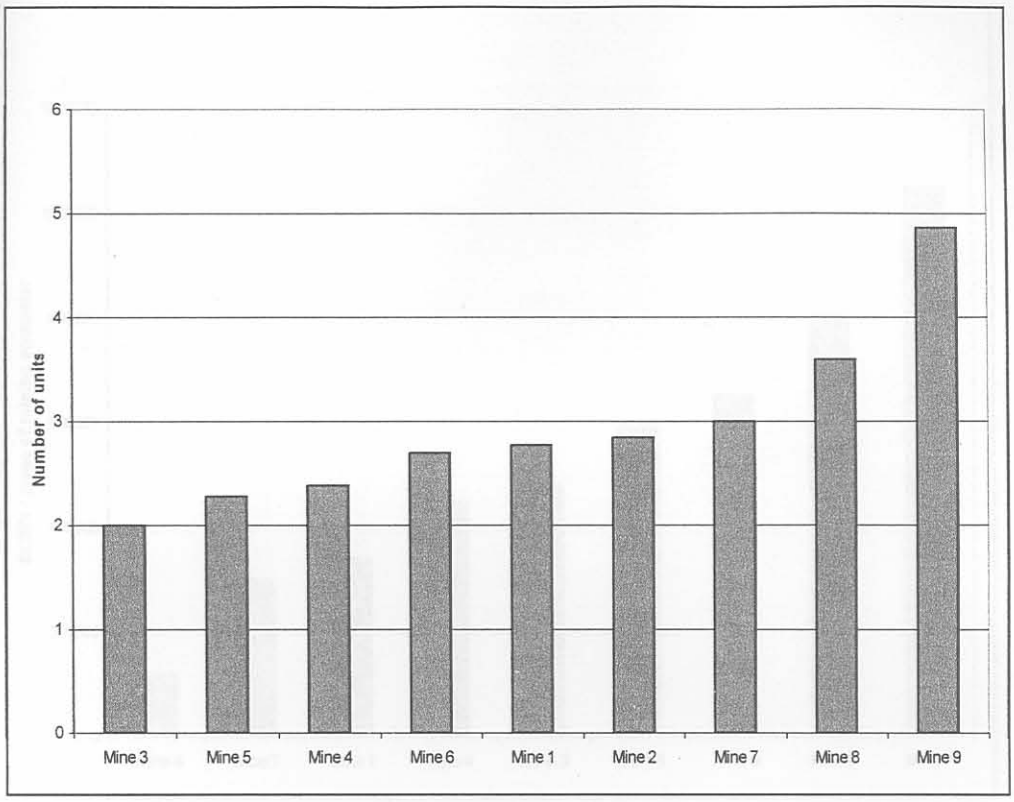


Figure 5: Number of primary equipment units per ancillary unit on South African mines

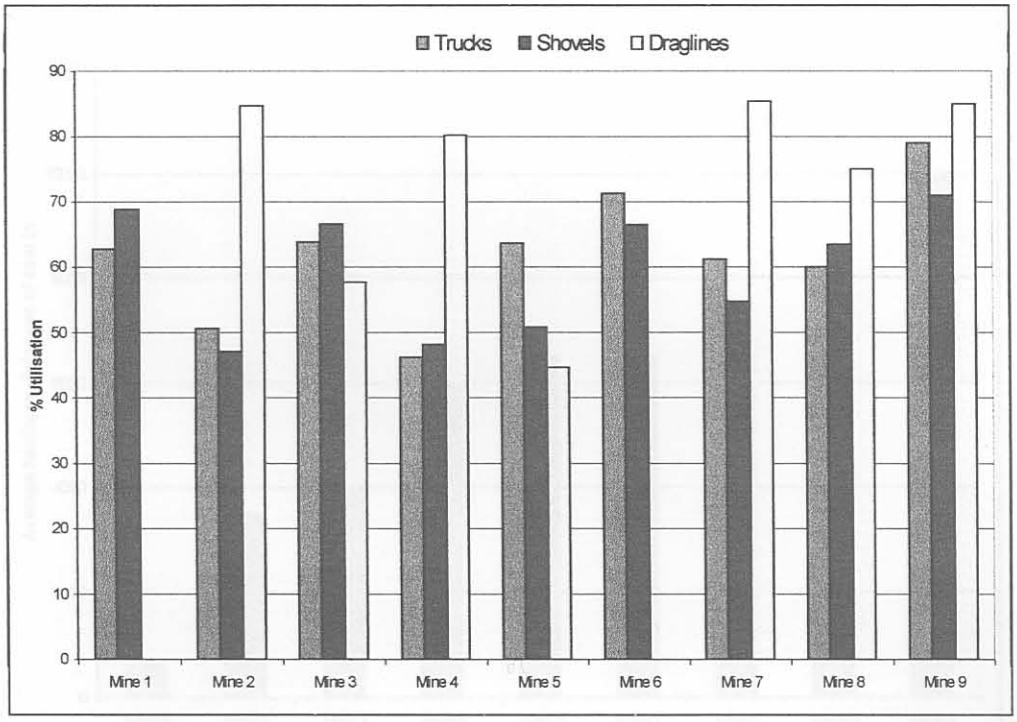


Figure 6: Equipment utilisation on South African mines

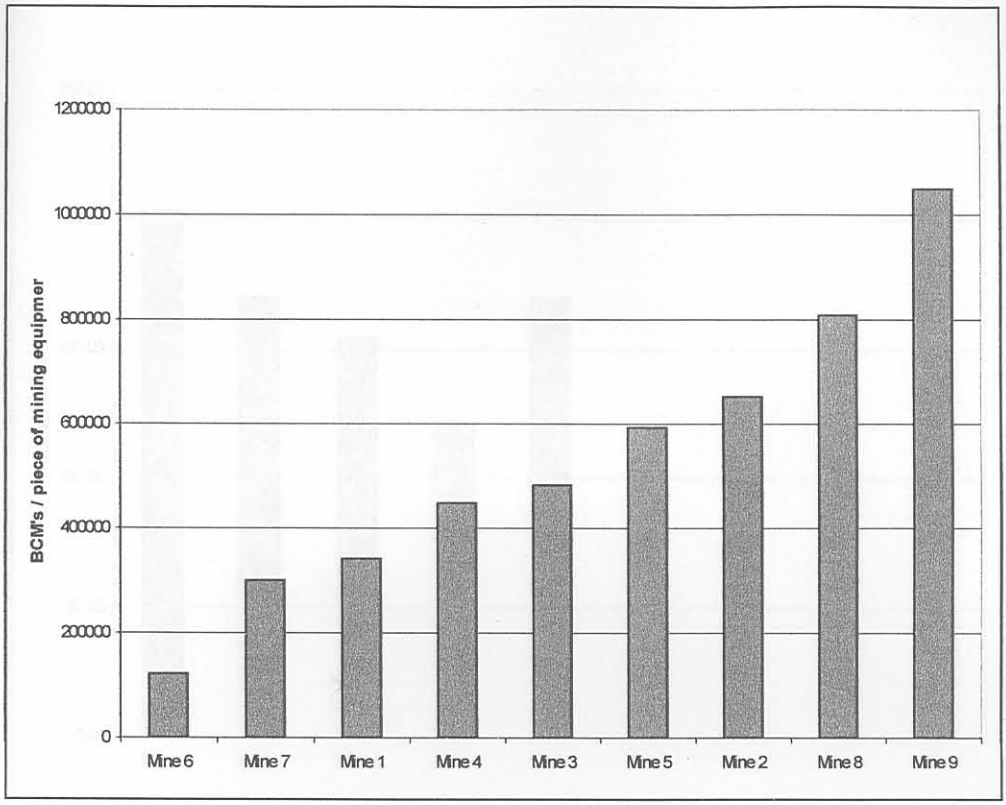


Figure 7: BCMs moved per mining equipment unit on South African mines

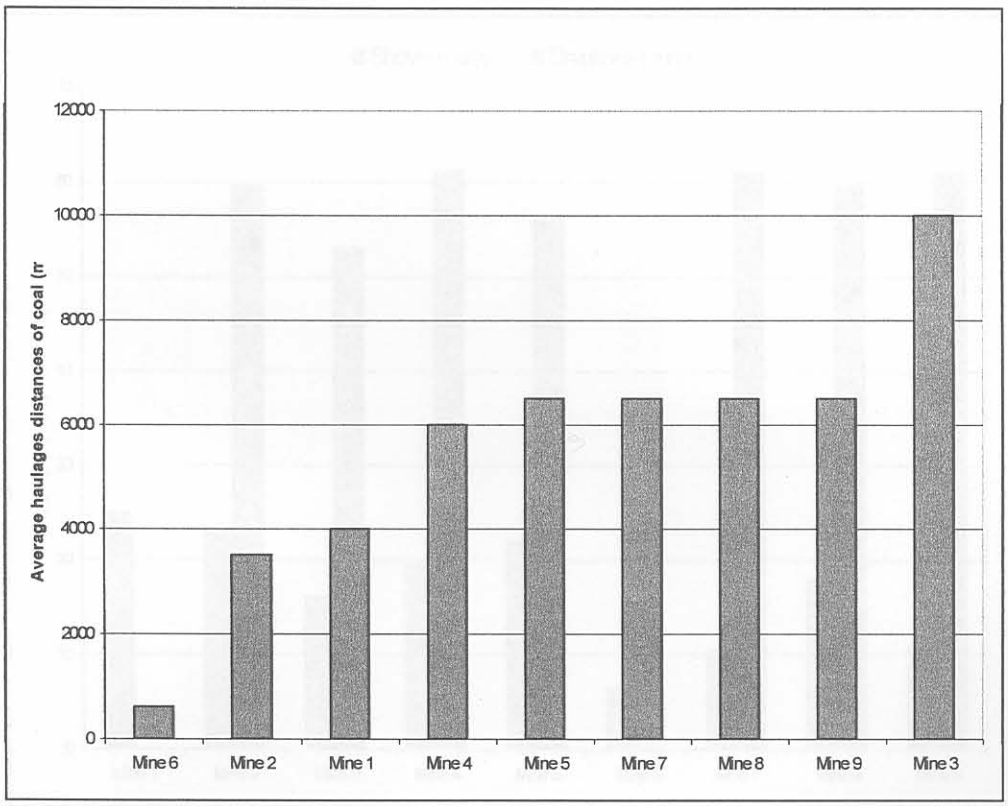


Figure 8: Average overburden haulage distances on South African mines

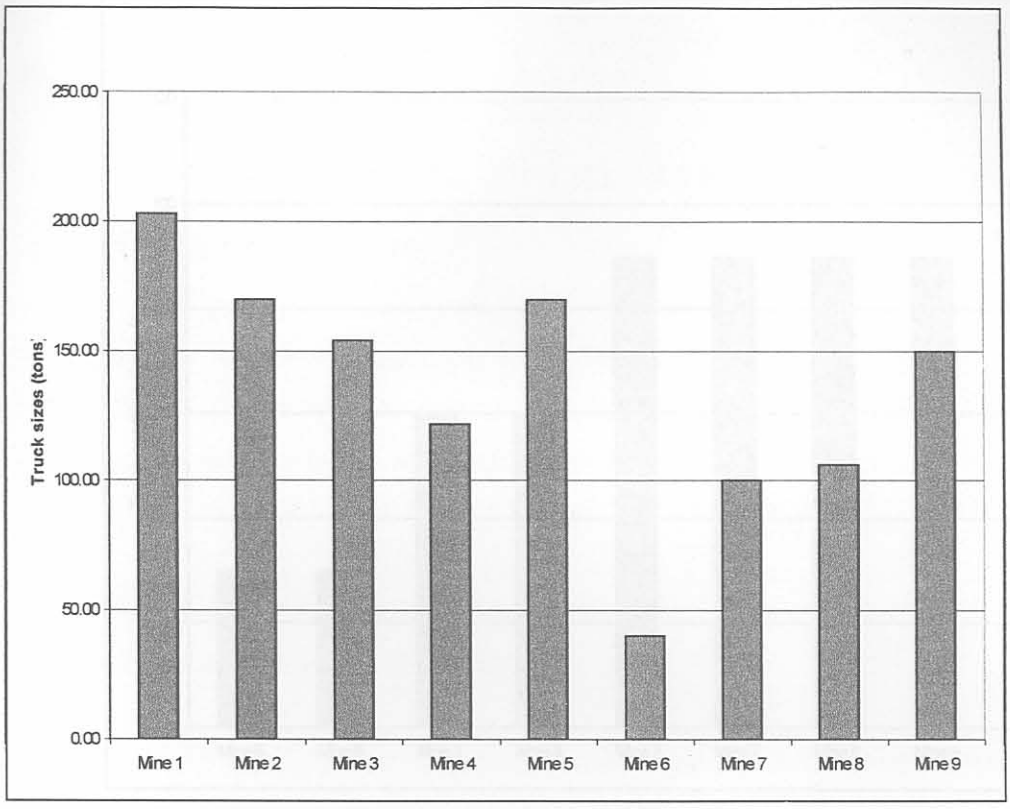


Figure 9: Sizes of haul trucks working on South African mines

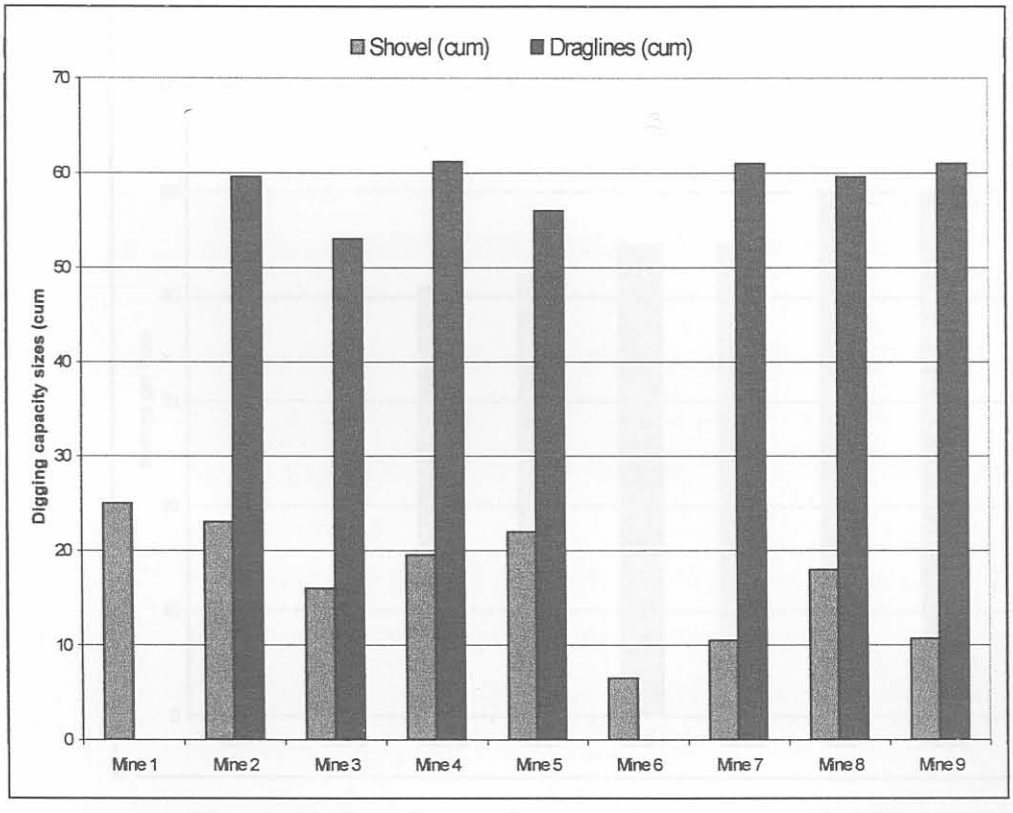


Figure 10: Digging capacity of shovels and draglines on South African mines

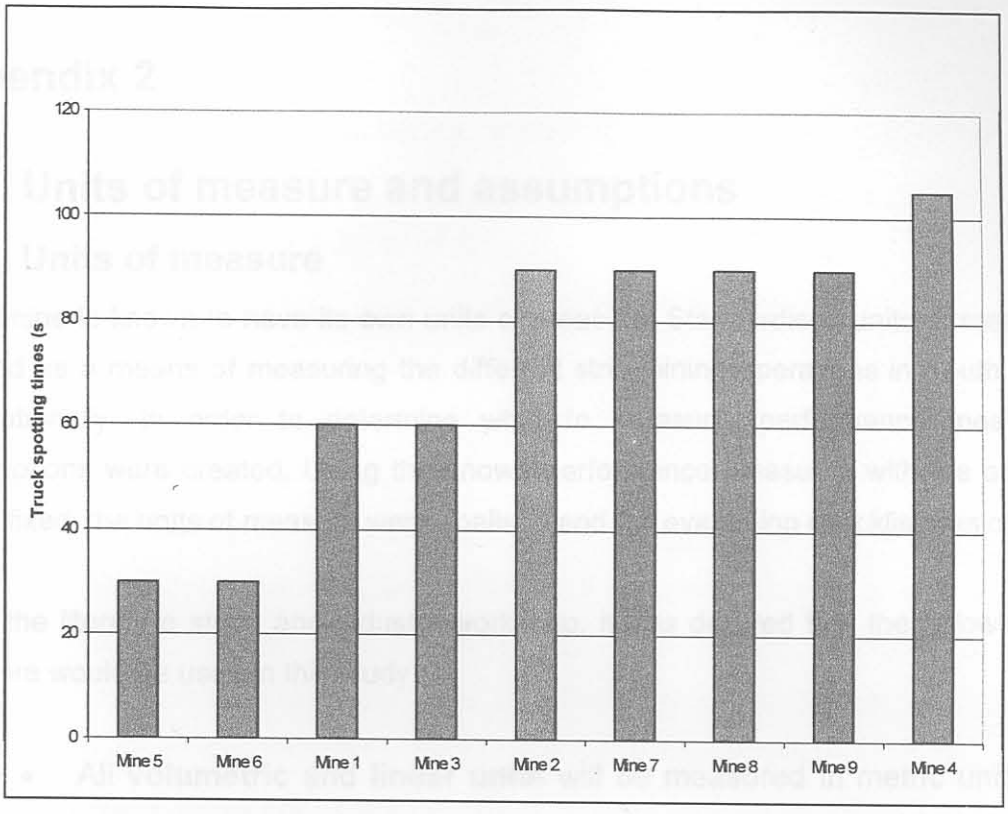


Figure 11: Truck spotting times on South African mines

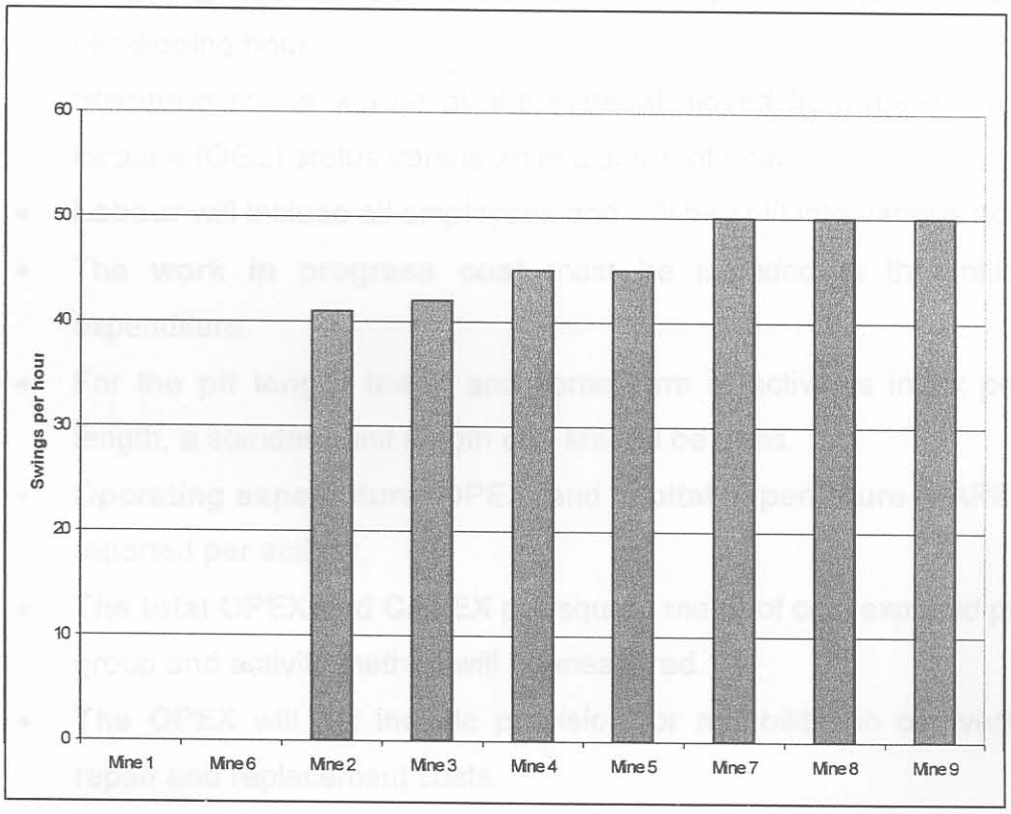


Figure 12: Dragline swings per hour on South African mines

Appendix 2

1. Units of measure and assumptions

1.1 Units of measure

Each mine is known to have its own units of measure. Standardised units of measure were created as a means of measuring the different strip-mining operations in South Africa and internationally. In order to determine what to measure, performance measures and assumptions were created. Using the known performance measures with the assumptions made fixed, the units of measure were finalised and the evaluation checklist was constructed.

From the literature study and industry workshop, it was decided that the following units of measure would be used in this study:

- All **volumetric** and **linear units** will be measured in metric units and not imperial units of measure.
- **Stripping rates** will be measured in BCMs per clock (calendar) hour and per digging hour.
- **Stripping ratios** will be all the material moved from the original ground location (OGL) status versus an in situ ton of coal.
- **Labour** will include all employees and will be split into various activities.
- The **work in progress cost** must be included in the initial capital expenditure.
- For the **pit length index** and some form of activities index per unit pit length, a standard unit length of 1 km will be used.
- **Operating expenditure** (OPEX) and **capital expenditure** (CAPEX) will be reported per activity.
- **The total OPEX and CAPEX** per square metre of coal exposed per activity group and activity method will be measured.
- **The OPEX** will not include provision for rehabilitation or overheads, or repair and replacement costs.

- **The CAPEX** will include repair and replacement, rehabilitation and overhead costs.
- **The seam dip** must be less than 10^{o}.

1.2 Assumptions made and fixed

For this study the following assumptions were made and fixed:

- Stripping evaluation will be based on the number of square metres of coal exposed per time frame.
- Processing costs must be dealt with as a separate issue.
- The cost curve should reflect OPEX per square metre of coal exposed.
- Direct OPEX should be used. This should exclude provision for rehabilitation and any other off-mine overheads. It must, however, include the provision made for repair and replacement (R&R).
- The capital cost for a stripping activity will be equal to the replacement value of that equipment. Thus the total capital deployed for a stripping activity will be equal to the sum of all the equipment-replacement costs for that activity.

Appendix 3

Benchmarking: Code of Conduct (BENSA, 1999)

1. Principle of ***legality***. Avoid discussions or actions that might lead to or imply an interest in restraint of trade, market or customer allocation schemes, price fixing, dealing arrangements, bid rigging, bribery or misappropriation. Do not discuss costs with competitors if costs are an element of pricing.

Keep it legal
Be willing to give what you get
Respect confidentiality
Keep information internal
Use benchmarking contacts
Don't refer without permission

2. Principle of ***exchange***. Be willing to provide the same level of information that you request in a benchmarking exchange.

3. Principle of ***confidentiality***. Treat benchmarking interchange as confidential to the individuals and organisations involved. Information that is obtained must not be communicated outside the partnering organisations without the prior consent of participating benchmarking partners. The fact that an organisation is participating in a study should not be communicated externally without its permission.

4. Principle of ***use***. Use the information obtained through benchmarking partnering only for the purpose of improving operations within the partnering organisations. External use or communication of a benchmarking partner's name with their data or observed practices requires permission from that partner. Do not, as a consultant or client, extend one organisation's benchmarking findings to another without the first organisation's permission.

5. Principle of ***first party contact***. Initiate contact, whenever possible, through a benchmarking contact designated by the partner organisation.

6. Principle of ***third party contact***. Obtain an organisation's permission before providing its name in response to a contact request.

7. Principle of **preparation**. Demonstrate commitment to the efficiency and effectiveness of the benchmarking process with adequate preparation at each process step, particularly at initial partnering contact.

Appendix 4

4.1 Additional information

Site visit: 1999- General and Truck & Shovel

Table 3.4.1a: Work practices in South African truck-and-shovel coal mines

	Practice
Total productivity	
3 Resource levels	
Staffing levels: ratio of labour hours worked to equipment hours worked	
Work time in shifts: time excluding leaving and joining shifts, meal and other breaks (per cent)	
Utilisation of truck fleet: hours operated as a percentage of total available hours	
Utilisation of major digging equipment: hours operated as a percentage of total available hours	
Work practices	
Hot-seat changes	
Meal breaks in the field	
Staggered meal breaks	
Operators move between equipment within shifts	
Haulage equipment fuelled in breaks	
Clean-up equipment does not impede production	

Table 3.4.1b: Key attributes of South African truck-and-shovel coal mines

	Practice mine
Efficient truck loading practices: incidence of double-sided or other efficient truck loading method (per cent)	
Spotting time of trucks under shovels (seconds)	
Truck loads per shovel per 8-hour shift	
Industrial disputes: days lost per thousand hours worked	
Safety: lost-time injuries per million man-hours	
Reportable per million man-hours	
Dressing station per million man-hours	
Fatalities per million man-hours	
4 General information	
Average round trip (m)	
Bonus scheme (no, bad or good)	

Dragline

Table 2.4.2: Productivity performance of dragline operations

	Dragline output per hour **(BCM)**	***Bucket factor*** **(%)**	***Swings per hour*** **(number)**	***Bucket capacity*** **(LCM)**	***Equivalent dragline bucketfuls*** **(number/h)**
Queensland coal	1 901	92	51	41	47

4.2 The stripping activity checklist

Step 1

	Asset register for stripping operation								
	Equipment type, make and name : **Drills**	**Hole size (mm)**	**No. of units**	**Length of drill steel (m)**	**No. of passes per drill hole**		**Design capacity (m/h)**	**Actual operating capacity (m/h)**	**Operating cost (R/h)**
1	e.g. Drill: O&K Drillteck 25 KS	170 mm hole	2	10	1,8		100	80	150
2									
3									
4									
5									
	Trucks	**Size (t)**	**No. of units**	**Dump body size (m^3)**	**Power of truck (kW)**	**Diesel rate (litres/ h)**	**Design capacity (m^3/h)**	**Actual operating capacity (m^3/h)**	**Operating cost (R/h)**
1									
2									
3									
4									
5									
	Shovels	**Size (SAE m^3)**	**No. of units**	**Digging force (kW)**	**Brake-out force (kW)**	**Diesel or electric**	**Design capacity in BCM (m^3/h)**	**Actual operating capacity in BCM (m^3/h)**	**Operating cost (R/h)**
1									
2									
3									
4									
5									
	Draglines	**Size**	**No. of units**	**Bucket size (SAE m^3)**	**Boom length (m)**	**Boom angle (°)**	**Design capacity (m^3/h)**	**Actual operating capacity (m^3/h)**	**Operating cost (R/h)**
1									
2									
3									
4									
5									

	Dozers	Size	No. of units	Blade capa-city (m^2)	Blade type (universal, straight/tilt, angle, etc.)	Blade capa-city (SAE m^3)	Design capacity (m^3/h)	Actual operating capacity and doze distance (m^3/h & m)	Opera-ting cost (R/h)
1									
2									
3									
4									
5									
	Ancillary	**Size**	**No. of units**	**Bucket size**	**Primary function**		**Design capacity (units/h)**	**Actual operating capacity (units/h)**	**Opera-ting cost (R/h)**
1									
2									
3									
4									
5									
6									
7									
8									

Step 2. Drills

	Drilling equipment utilisation on stripping operation							
		% of time spent by equipment type as listed in Step 1 on stripping activity						
		e.g. O&K Drillteck 25 KS						
1	**Stripping activity**	-						
	Bush clearing	-						
	Topsoil removal	-						
	Subsoil removal	-						
	Highwall control	-						
	Blasting	-						
	Pre-stripping	15						
	Primary stripping	60						
	Coaling	5						
	Parting	15						
	Rehabilitation							
	Other	5						
2	**Total time on activity**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
3	**Annual hours lost / equipment to:**							
	Shift change							
	Maintenance Planned							
	Maintenance Unplanned							
	Dead headings							
	Pad preparation							
	Relocation of equipment							
	Blasting							
	Other							
4	**Total annual hours lost per equipment**							
5	**Annual additional operating hours**							
	Sundays							
	Holidays							

Step 2. Trucks

	Truck equipment utilisation on stripping operation							
		% of time spent by equipment type as listed in Step 1 on stripping activity						
		e.g. CAT 777 (85t)						
1	**Stripping activity**							
	Bush clearing							
	Topsoil removal	10						
	Subsoil removal	60						
	Highwall control							
	Blasting							
	Pre-stripping							
	Primary stripping							
	Coaling							
	Parting							
	Rehabilitation							
	Other	30						
2	**Total time on activity**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
3	**Annual hours lost / equipment to:**							
	Shift change	100						
	Maintenance - planned	1 000						
	Maintenance - unplanned	250						
	Dead headings	0						
	Pad preparation	0						
	Relocation of equipment	0						
	Blasting	500						
	Other	120						
4	**Total annual hours lost per equipment**	1 970						
5	**Annual additional operating hours**							
	Sundays	0						
	Holidays	0						

Step 2. Shovels

	Equipment utilisation on stripping operation							
		% of time spent by equipment type as listed in Step 1 on stripping activity						
		e.g. Cat 994 (20m3)						
1	**Stripping activity**	-						
	Bush clearing	-						
	Topsoil removal	-						
	Subsoil removal	-						
	Highwall control	-						
	Blasting	-						
	Pre-stripping	-						
	Primary stripping	-						
	Coaling	80						
	Parting	15						
	Rehabilitation							
	Other	5						
2	**Total time on activity**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
3	**Annual hours lost / equipment to:**							
	Shift change	100						
	Maintenance - planned	1 200						
	Maintenance - unplanned	300						
	Dead headings	0						
	Pad preparation	0						
	Relocation of equipment	0						
	Blasting	1 000						
	Other	100						
4	**Total annual hours lost per equipment**	2 700						
5	**Annual additional operating hours**							
	Sundays	500						
	Holidays	120						

Step 2. Draglines

	Equipment utilisation on stripping operation							
		% of time spent by equipment type as listed in Step 1 on stripping activity						
		e.g. Dragline						
1	**Stripping activity**							
	Bush clearing							
	Topsoil removal							
	Subsoil removal							
	Highwall control							
	Blasting							
	Pre-stripping							
	Primary stripping	100						
	Coaling							
	Parting							
	Rehabilitation							
	Other							
2	**Total time on activity**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
3	**Annual hours lost / equipment to:**							
	Shift change	50						
	Maintenance Planned	500						
	Maintenance Unplanned	100						
	Dead headings	70						
	Pad preparation	50						
	Relocation of equipment	150						
	Blasting	200						
	Other	0						
4	**Total annual hours lost per equipment**	1 120						
5	**Annual additional operating hours**							
	Sundays	600						
	Holidays	288						

Step 2. Dozers

	Equipment utilisation on stripping operation							
		% of time spent by equipment type as listed in Step 1 on stripping activity						
		e.g. Dozer						
1	**Stripping activity**							
	Bush clearing	20						
	Topsoil removal	40						
	Subsoil removal							
	Highwall control							
	Blasting							
	Pre-stripping							
	Primary stripping							
	Coaling							
	Parting							
	Rehabilitation	40						
	Other							
2	**Total time on activity**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
3	**Annual hours lost / equipment to:**							
	Shift change	200						
	Maintenance - planned	1 000						
	Maintenance - unplanned	500						
	Dead headings	0						
	Pad preparation	0						
	Relocation of equipment	0						
	Blasting	0						
	Other	100						
4	**Total annual hours lost per equipment**	1 800						
5	**Annual additional operating hours**							
	Sundays	0						
	Holidays	0						

Step 2. Ancillary

	Equipment utilisation on stripping operation							
		% of time spent by equipment type as listed in Step 1 on stripping activity						
		e.g. Watercar						
1	**Stripping activity**	-						
	Bush clearing	-						
	Topsoil removal	-						
	Subsoil removal	-						
	Highwall control	-						
	Blasting	-						
	Pre-stripping	-						
	Primary stripping							
	Coaling	70						
	Parting	20						
	Rehabilitation							
	Other	10						
2	**Total time on activity**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
3	**Annual hours lost / equipment to:**							
	Shift change	120						
	Maintenance - planned	1 000						
	Maintenance - unplanned	200						
	Dead headings	0						
	Pad preparation	0						
	Relocation of equipment	0						
	Blasting	0						
	Other	50						
4	**Total annual hours lost per equipment**	1 370						
5	**Annual additional operating hours**							
	Sundays	0						
	Holidays	0						

Step 3

	Labour sheet	
1	**Time**	*Annual hours*
	Annual available hours	8 760
	- Annual external hours lost:	
	Sundays	
	Holidays	
	Weather	
	Other	
2	**Annual hours available for production**	
3	**Labour**	**Number of people**
	Total labour component on mine	
	Management	
	Plant labour	
	Human resource labour	
	Plant maintenance labour	
	Mining maintenance labour	
	Admin. labour	
	Services labour	
	Non-mining contractors	
	Other	
	Total labour in mining	
	+ Bush clearing	
	+ Topsoil removal	
	+ Subsoil removal	
	+ Pre-stripping	
	+ Highwall control	
	+ Drilling	
	+ Blasting	
	+ Primary stripping	
	+ Coaling	
	+ Parting	
	+ General labour (pump, road crew, etc.)	
	Mining contractors	

Step 4

Production sheet								
1	**Production activity**	**Area cleaned / annum (m^2/annum)**	**BCMs moved / annum (m^3)**	**TCMs moved per annum**	**% Rehandle (as % of BCMs moved)**	**% Blast gain (as % of BCMs moved)**	**Powder factor (kg/m^3)**	**Total cost / annum**
	Bush clearing							
	Topsoil removal							
	Subsoil removal							
	Highwall control							
	Blasting							
	Pre-stripping							
	Primary stripping							
	Coaling							
	Parting removal							
	Rehabilitation							
	Survey method							
2	**Total production**							
		Length (m)	**Width (m)**					
3	**Pit 1**							
	2							
	3							
	4							
4	**Total length of pit mined per annum (m)**							

***Please complete a production sheet for each stripping operation.**

Step 5

	Geology sheet					
1	**Coal seam**					
	Name	**Thickness (m)**	**Effective stripping ratio**	**Depth below surface (m)**	**m^2 coal exposed / annum**	**Actual stripping ratio**
	1					
	2					
	3					
	4					
	5					
	6					
2	**Information**	**Material thickness (m)**	**Bench height (m)**	**In situ density(t/m^3)**	**Compressive strength (MPa)**	**Blasted or free digging**
	Bush clearing					
	Topsoil: Softs					
	Hards		---			
	Subsoils: Softs					
	Hards		---			
	Pre-stripping: Softs					
	Hards		---			
	Primary stripping: Softs					
	Hards		---			
	Coal seam 1					
	Coal seam 2					
	Coal seam 3					
	Coal seam 4					
	Coal seam 5					
	Parting 1					
	Parting 2					
	Parting 3					
	Parting 4					
	Parting 5					

Step 1

This step involves listing the capital equipment needed to do the stripping of overburden, coal and interburden material for the last financial year. This is done by:

1.1 Listing all the equipment involved with the stripping operation. For each piece of equipment:

- Give its full name and description as outlined by the equipment supplier.
- Describe the equipment size in carrying capacity, full size, blade size, etc.
- Describe the bucket size of the dump body, bucket, etc. in volumetric units (m^3) and push blades of dozer in cubic metres (m^3).
- The amount or number of the same units in operation or active in the stripping process.
- Give the design capacity of the equipment as indicated by the equipment supplier in BCM, metres, etc. per operating hour.
- Give the operating capacity of the equipment by obtaining the BCMs moved or metres drilled by the equipment per annum and dividing that by its annual total hours obtained from Step 2.
- Adding all the fixed and variable costs per hour associated with the equipment will result in the total cost per hour. This cost figure should include associated labour, maintenance, fuel and electricity costs and provision for repair and overhaul cost. It should exclude overhead and replacement costs.

Step 2

This step involves listing for each piece of equipment its annual time in hours spent on each stripping activity and annual time in hours lost due to internal stoppages for the last financial year. Each equipment group listed in Step 1 has its own Step 2 form.

2.1 The time spent on each activity is done by:

- Listing each equipment type in the equipment row.

- Determining the percentage of time each item of equipment spends on the associated stripping activity as a percentage of its total operating hours (no time allowed for time losses).

2.2 The sum of the time spent by each item of equipment on each mining activity must be 100%.

2.3 The annual internal hours per equipment type lost to shift change, maintenance - planned, maintenance - unplanned, dead headings, pad preparation, relocation of equipment, blasting and other hours lost is expressed in annual hours and is obtained from the record-keeping system on or of each machine type.

2.5 Adding the equipment operating hours for public holidays and Sundays will give the additional operational hours per annum.

Step 3

This step involves listing the time available for production and the labour component on the mine that was involved in each department for the last financial year.

3.1 The time calculation is done by:

- Using the annual calendar hours (calendar hours = 8 760).
- Deducting the annual external hours lost will result in the annual hours available for production.
- Adding the time in hours lost to Sundays, public holidays and weather conditions will result in the annual external hours lost.

3.2 The labour calculation is done by:

- Listing the labour component for each department on the mine.
- Adding the number of people listed in each department row will result in the total labour on the mine.

- Dividing the mining labour into the number of labour associated with each stripping activity will result in the associated number of people/labour employed per activity.

Step 4

This step involves listing the annual square metres of area cleared, the BCMs moved, the percentage rehandle, the percentage blast gain, the total cost for each mining activity and the powder factor realised by blasting for each associated activity active during the previous financial year.

4.1 The production activity projections are done by:

- Multiplying the width of the cut by the total length of material cleared per annum for each stripping activity will result in the area cleared per annum.
- Multiplying the area cleared per annum by the associated total thickness will result in the BCMs moved per annum for each stripping activity.
- Total cubic metres (TCMs) is the total volume of BCMs moved by the equipment.
- Dividing the BCMs rehandled by the total amount of BCMs moved per annum will result in the percentage of BCMs rehandled.
- Dividing the BCMs moved by blasting by the total amount of BCMs moved per annum will result in the percentage blast gain.
- Dividing the kilograms of explosives used by the associated BCM will result in the powder factor.
- Adding all the total fixed and total variable costs associated with each activity will result in the total cost per annum. This cost figure should include associated labour, maintenance, fuel, electricity costs and provision for repair and overhaul costs. It should exclude overhead and replacement costs.

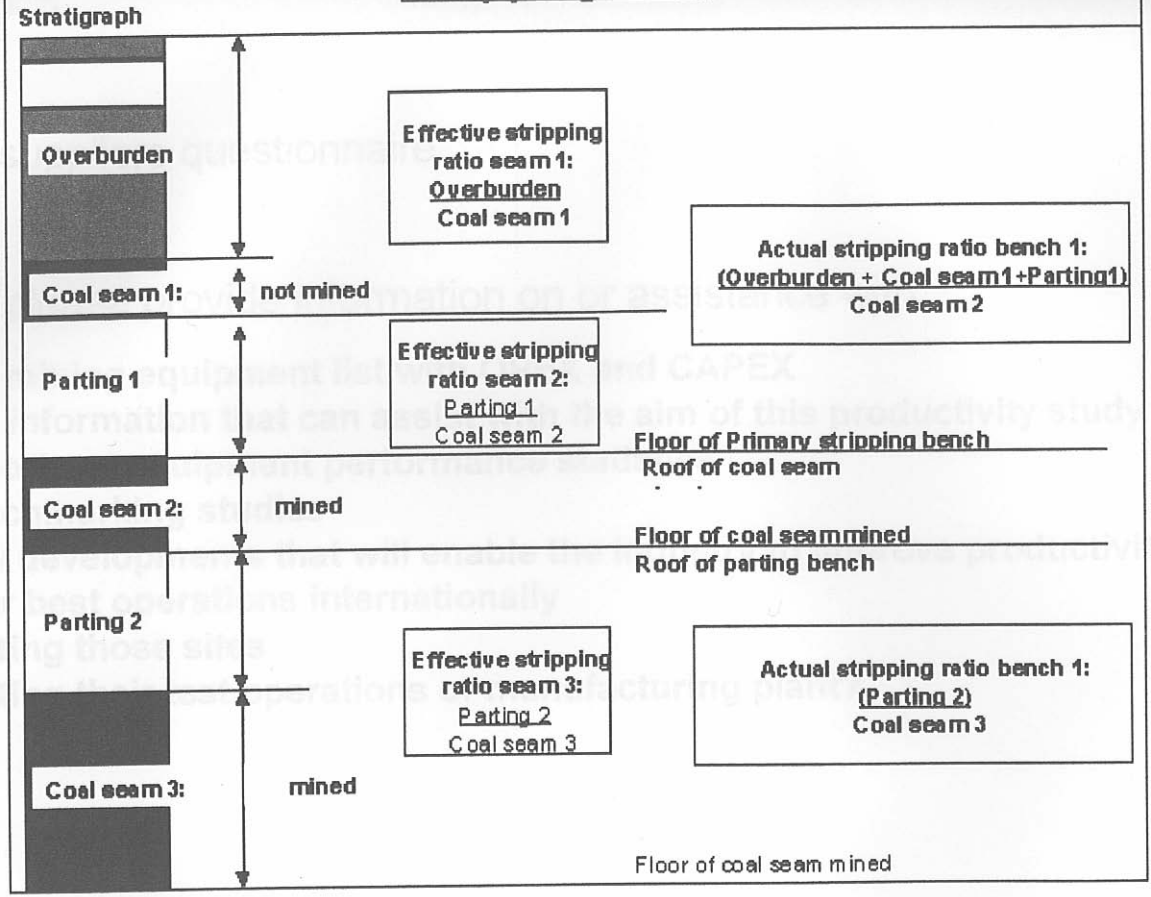
Step 5

This step involves listing the geological conditions present on the mine during the last financial year.

5.1 The information projections for the coal seams are done by:

- Listing all the coal seams present in each stripping operation and listing each one's associated thickness in metres.
- To calculate the effective stripping ratio of each coal seam, see Figure 1. The effective stripping ratio is derived by dividing a coal seam's overlying waste material thickness in metres by the coal seam's thickness in metres.
- Listing the depth from surface to the top of each coal seam for the depth below surface.
- Multiplying the width of the cut by the total length of a coal seam exposed per annum will result in the m^2 of coal exposed/annum.
- To calculate the actual stripping ratio of each coal seam mined, see Figure 1. The actual stripping ratio is derived by dividing the BCMs by the in situ mineable coal tons available in that pit.

Stripping ratio



Appendix 5

Industry suppliers questionnaire.

Can you please provide information on or assistance with:

- **Full mining equipment list with OPEX and CAPEX**
- **Any information that can assist with the aim of this productivity study**
- **Reports or equipment performance statistics**
- **Benchmarking studies**
- **New developments that will enable the industry to improve productivity**
- **Your best operations internationally**
- **Visiting those sites**
- **Visiting their test operations or manufacturing plant?**