# Campaign mining set-up for waste stripping at New Vaal Colliery

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## Synopsis

The objective of the investigation is to optimize the truck and shovel operations for pre-stripping at New Vaal Colliery by introducing campaign mining. The aim of campaign mining is to improve the efficiency of the loading, hauling, dumping, and maintenance operations which are critical to the success of truck and shovel operations. The current loading (single-sided loading method), hauling, and dumping operations at New Vaal Colliery were found to be inefficient. Time studies were used as a major indicator to highlight the inefficiency of the truck and shovel operations, and it is recommended that an improved loading configuration, hauling, and dumping operations be implemented by using campaign mining. It is also recommended that a service truck be used to maintain the pre-stripping fleet in order to reduce travelling times to the main workshop. As expected, the improved operating conditions will lead to an increase in pre-stripping production.



Keywords

campaign mining, efficiency, bank cubic metres (BCMs), truck and shovel.


## Introduction

This project was undertaken during the vacation period of November 2011 to January 2012. At that time, New Vaal Colliery needed to find a way to increase the 2012 pre-stripping production in order to meet a run of mine (RoM) target of 17.8 Mt of coal per annum. In order to meet the RoM production target planned for 2012, management decided to introduce the concept of campaign mining, which focuses on the effective utilization of the truck and shovel operations. The concept of campaign mining originated from collieries such as Drayton and Callide in Australia, and New Vaal Colliery is the first colliery in South Africa to implement this type of operation. The main advantage of campaign mining is that it focuses on improving all aspects truck and shovel operation, such as loading, hauling, dumping, and maintenance, and not merely on a single aspect. This results in an interlocked improvement of waste stripping operations, which is more efficient than if only one operation was targeted. Due to the scope of this project, only the aforementioned operations will be investigated.

## Mine background

New Vaal Colliery is situated south of Vereeniging on the bank of the Vaal River on the farm Maccauvlei. It is about 70 km south of Johannesburg. New Vaal Colliery is an opencast mining operation that uses draglines for waste removal, and truck and shovel for both pre-stripping and coaling operations. Figure 1 shows the location of New Vaal Colliery with Eskoms' Lethabo power station nearby. The colliery is located in the Vereeniging-Sasolburg, coalfield, which was discovered by George Stow in 1878. From 1931 to 1969 the coal deposit was mined by an underground bord and pillar mining method by a company called Cornelia (Gilfillan, 2011). During 1978, the reserves were re-evaluated and in 1983, New Vaal Colliery was established and began operations in December 1985 (Gilfillan, 2011).

### *Mining operations*

New Vaal Colliery is a surface mining operation that uses truck and shovel for pre-stripping soft overburden i.e. sand. The colliery has three different pits: namely North, South, and West pit with a dragline in each pit. The draglines remove the hard overburden from the pit and place it on the spoil heap. The mining operation at New Vaal Colliery is divided into three sections: namely Sand Stripping, Draglines, and Coaling.

To pre-strip the sand both the bucketwheel excavator (sand system), which moved 1.5 million bank cubic metres (BCMs) during 2009, and the truck and shovel fleet, which moved 4.0 million BCMs in the same year, are used. In October 2010, the bucketwheel excavator was scrapped after reaching a life of 25 years. The soft overburden is now removed using truck and shovel only. A fleet of seven


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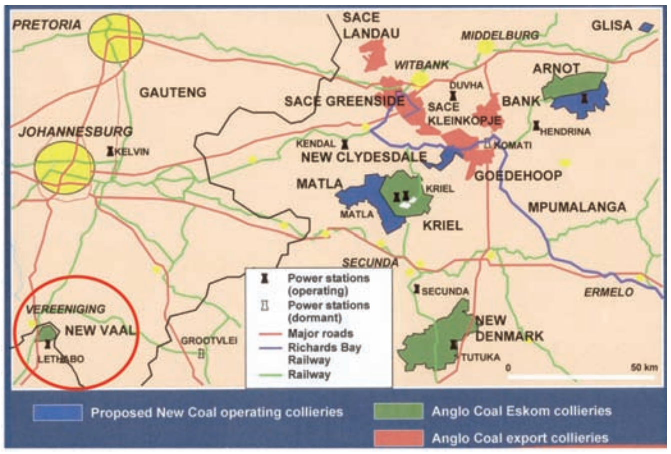



Figure 1—Location of New Vaal Colliery and Lethabo Power Station (Gilfillan, 2011)

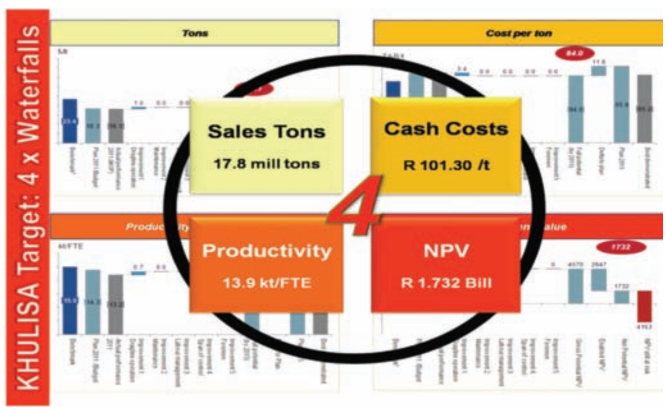



Figure 2—New Vaal Colliery targets for 2012 (New Vaal Colliery, 2011)

Euclid R170 rear dump haul trucks and three P&H rope shovels are used for sand stripping operations, with one of the shovels on standby. The coaling fleet consists of five Hitachi EH 3500 and five Cat 789 rear dump trucks, combined with four Demag 285 hydraulic shovels (front end loaders) and one rope shovel. In total there is a fleet of eight shovels at New Vaal Colliery, consisting of four rope shovels and four Demags. The hard overburden and the top seam are drilled and blasted together, followed by the interburden and the middle seam, and finally the parting and the bottom seam. New Vaal Colliery uses the dispatch system to monitor, record, and direct mining operations.

## Project background

New Vaal Colliery is the highest producer of run of mine (RoM) coal in Anglo American Thermal Coal. In 2011, a target of 17.3 Mt of coal per annum was set, and the actual coal produced was above 17.4 Mt/a. For New Vaal Colliery to achieve this target, a total of 28.6 million bank cubic metres (BCMs) of sand had to be moved, 5.5 million BCMs of which was moved by truck and shovel and the remainder by the draglines. A target of 17.8 Mt RoM (see Figure 2) coal is planned for 2012. To achieve this RoM target, a total of 30.5 million BCMs of sand/waste have to be excavated. Out of that target, 7.5 million BCMs has to be moved by truck and shovel and the remainder will be moved by the draglines. The more sand that is pre-stripped the more productive the dragline becomes. This is because the dragline will re-handle less material and thus expose more coal, which will enable New Vaal Colliery to reach its 2012 RoM target. To ensure that the truck and shovel fleet achieves the improved target, the concept of campaign mining was introduced.

### *Campaign mining*

Campaign mining is a method of mining where truck and shovel operations are prioritized with the aim of increasing their productivity and efficiency. This method of mining, which has not previously been applied in South Africa, is currently being practised in Australia and South America (Gilfillan, 2011).

Campaign mining involves the prioritization of trucks and shovels in circuits. The circuits are classified in terms of importance, from priority 1 to priority 3. The priority 1 circuit will utilize the best equipment and operators. If equipment breaks down in priority 1, whether a dozer, grader, or haul truck, equipment will be assigned from either priority 2 or 3 circuits in order to keep the priority 1 circuit running as consistently and efficiently as possible. The circuits are closed off from other fleets (coal haul trucks) and open only to the sand stripping trucks in this case.

### Project scope

This paper describes an investigation on the current New Vaal Colliery operating conditions. Time studies were conducted on the truck and shovel sand stripping operations and the results were compared to the campaign mining targets to determine if the mine's production is in line with the desired target. The mining operations, including loading, hauling, and dumping operations, were observed and analysed to determine how they could be made more efficient. Other service operations such as maintenance were also investigated to determine how they could aid in making campaign mining a success.

### Project objectives

For campaign mining to be successful, ideal operating conditions are required. The aim of this project was therefore to:

- Determine the most efficient loading configuration
- Determine the benefits of having well maintained haul roads
- Design a more efficient dumping methodology
- Identify the additional resources required to make campaign mining a success.

### Methodology

The methods used to conduct the project are as follows:

- *Measurement and observation*—time studies of truck and shovel fleet were conducted as well as general observations of these operations
- *Personal communication*—extensive consultations with relevant personnel at the mine as well as at the University of the Witwatersrand
- *Literature research*—a literature search was conducted on the ideal operating conditions of a typical truck and shovel fleet, data was collected at the mine and analysed, and other service departments were consulted to aid in making this project a success.

### Results

Table I shows the current key performance indicators (KPIs) at New Vaal Colliery and the target KPIs for campaign mining. The travelling times depend on the distance between the loading area and the dumping area. The hauling distance used in Table I is approximately 1.2 km.

#### *Loading*

The sand fleet at New Vaal Colliery uses a single-sided loading method (see Figure 3). The average spotting time for the trucks is 52 seconds, as shown in Table I. This value is 7 seconds more than the spotting time targeted for campaign mining. During campaign mining, the current spotting time will affect the consistency of the operation significantly, and hence the production will also be adversely affected. Figure 4 shows how production in BCMs will be adversely affected on a six-monthly window by current spotting times during campaign mining. The production lost due to the long spotting times is cumulative, hence it is important to keep spotting times as low as possible. Figure 4 is based on sand production during the period in which the project was conducted.

Table I also shows that the current loading time of 95 seconds is similar to that required for campaign mining. This is because the operators apply best practice loading techniques by swinging the shovel bucket by a maximum of 90° from digging to loading into the trucks (Thompson, 1996). This swing angle (90°) of the shovel bucket results in a performance output of 100% (see Figure 5). To further improve the efficiency of the loading operations, an alternative single-sided loading configuration can be used (see Figure 6). This loading configuration will enable swinging angles to be as low as 30°, which will result in a performance output of more than 126% according to research conducted by Havenga (2011). This loading configuration will also reduce spotting times because trucks will be turning at an angle of approximately 60° to spot. This angle is significantly less than the 70°–90° turn the trucks are currently doing to spot.

#### *Hauling*

Haul road conditions affect cycle times immensely. Poor haul road conditions (due to infrequent grading and watering), with potholes, steep gradients, sharp curves, and insufficient

Figure 3—Current single-sided loading method

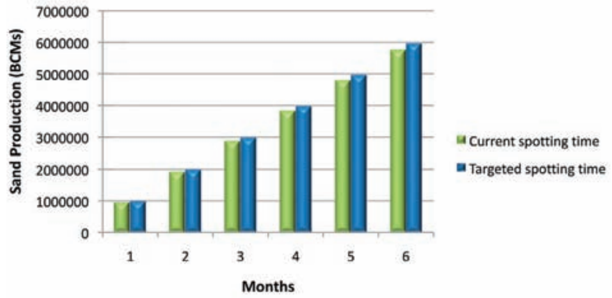
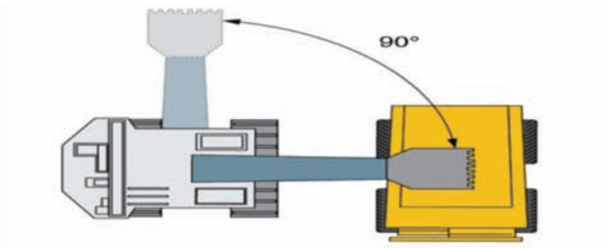



Figure 4—Current vs targeted spotting time

*Table I*

**Key performance indicators**

| Parameters | Current | Campaign mining targets |
|---|---|---|
| Spot time (s) | 52 | 45 |
| No of passes (s) | 3 | 3 |
| Load time (s) | 95 | 95 |
| Travel full (s) | 220 | 220 |
| Dumping time (s) | 83 | 60 |
| Travel empty (s) | 196 | 195 |
| Total cycle time (s) | 714 | 683 |




| Degrees of Swing | Approximate Resulting % of Maximum Output |
|---|---|
| 45° | 126% |
| 60° | 116% |
| 75° | 107% |
| 90° | 100% |
| 120° | 88% |
| 150° | 77% |
| 180° | 70% |

Figure 5—Effect of swing angle on productivity (Havenga, 2011)

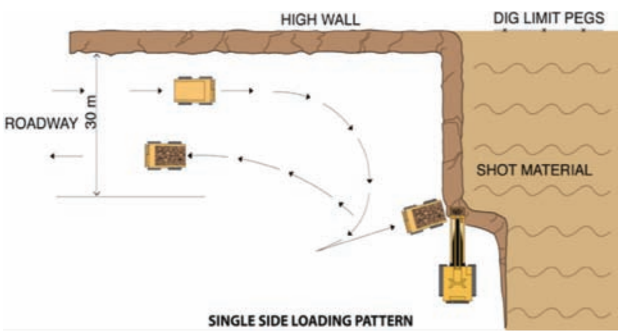



Figure 6—Single sided loading method (Havenga, 2011)

width etc.) increase cycle times and induce damage (due to potholes) on trucks (hydraulics), thus increasing the number of unplanned breakdowns, which will impact the efficiency of the operation (Runge, 1983). Poor haul roads also induce fatigue in truck operators and thus additional fatigue breaks will be required.

Good road conditions, on the other hand, (i.e. frequently graded and watered, potholes filled, fair gradients, smoothed curves, and sufficient width) reduce cycle times (Tannant and Regensburg, 2001). For campaign mining to be successful, haul roads will have to be continuously maintained to reduce operator fatigue and unplanned breakdowns, thus increasing the efficiency of the operation. This will be accomplished because campaign mining circuits will be allocated designated equipment such as dozers and graders to maintain the haul roads. When the dozer or grader is due for daily maintenance, alternative equipment from other sections (coaling) will be allocated to campaign mining circuits if necessary.

Field investigations show that on a 1 km straight haul road, trucks travel at average speeds of 30 km/h and 40 km/h in poor and good road conditions respectively. These speeds are used to show the implications of poor road conditions on production output (see Figure 7).

Figure 7 shows how poor haul road conditions affect production (cumulative). Figure 7 is based on sand production during the period in which the project was conducted. The amount of production lost will depend on the distance between the loading area and the dumping area. This is because the greater the distance travelled on poor road conditions, the more time, and hence the more production, that will be lost.

### *Stop signs*

As mentioned previously, campaign mining circuits should operate continuously. For this to happen, stop signs should not be present in campaign mining circuits. This is possible because only the sand fleet will operate in the circuits, which are closed to other fleets in the mine, hence the probability of accidents is reduced. Exclusion of stop signs from campaign mining circuits will also increase production because no time will be lost by trucks stopping at stop signs every cycle. Figure 8 shows how stop signs affect production (cumulative). Figure 8 is based on sand production during the period in which the project was conducted. The amount of production lost will depend on the number of stop signs in the circuits.

### ***Dumping methodology***

The dumping areas at New Vaal Colliery were at times not well maintained. This was caused by sand dumps taking up part of the haul road because they were not being pushed into the dumping hole, and thus the dumping area could not be graded. This resulted in trucks taking longer than necessary to dump because they had to negotiate the poor conditions that had formed.

Table I shows that the current dumping time at New Vaal Colliery is 23 seconds more than the targeted time of 60 seconds for campaign mining. The reason for unmaintained dumping areas was the unavailability of the dozer. Since campaign mining will be allocated designated equipment, the dozer will be available to maintain the dumping area. Consistent maintenance of the dumping area will ensure that the targeted dumping time is achieved. To maximize the operation of the dozer and reduce the dumping time, a dumping plan as shown in Figure 9 has been proposed.

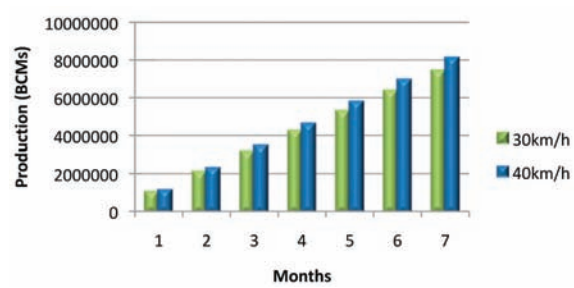



Figure 7—Loss of production due to poor haul road conditions

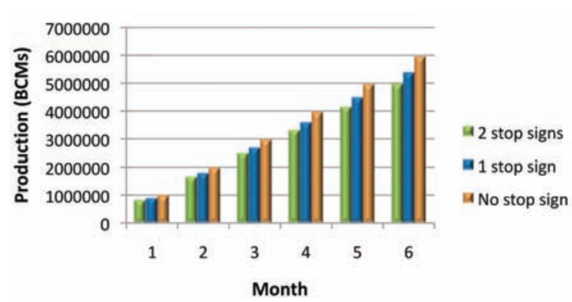



Figure 8—Effect of stop signs on production

With the improved plan, trucks will travel only on the area outlined by the arrows, and only this area will be maintained by the dozer and grader. This is done so as to not waste time maintaining areas where the trucks will not travel (area encircled by the arrows). The trucks will enter the dumping area through a designated entrance road and leave the area after dumping through a designated exit road. Figure 10 shows how the proposed dumping area will affect production. Figure 10 is based on sand production during the period in which the project was conducted.

### *Dozer availability*

Figure 9 shows that trucks dump on the edge of the waste hole. The dozer will push the sand dumps into the hole. The dozer allocated to campaign mining has been observed to be capable of pushing up to two rows of sand dumps efficiently. When there are more than two rows of sand dumps, the dozer will hus not be able to keep up with the rate at which the trucks dump. To determine how long it will take trucks to create two rows of dumps, the parameters shown in Table II are required. The length of the dumping area for this particular circuit was obtained from the surveying department of New Vaal Colliery.

The time to create two rows of dumps for this particular circuit was estimated to be approximately 2 hours. This means that the dozer can be away from the dumping area for a maximum of two hours before the operation becomes inefficient.

## *Additional services*

New Vaal Colliery uses only one workshop for maintenance of their machinery. All machinery at the mine has to travel from the working area to the workshop at least once a day for maintenance. This distance increases as mining progresses. The increased travelling time reduces the effective operating/production time of the machinery and thus reduces the efficiency of operations. Currently the sand fleet at New Vaal Colliery travels 6 km on average from the working areas to the workshops. The trucks travel at an average speed of 35 km/h (including stops at stop signs), as measured using a global positioning system (GPS) and using the relationship

$$v = \frac{s}{t}$$

where
$v$: speed (m/s)
$s$: distance travelled (m)
$t$: time (s).

The time spent travelling to the workshop was calculated to be 10 minutes and 17 seconds, or approximately 20 minutes and 30 seconds for a round trip. To minimize or eliminate the time spent by trucks travelling to the workshops, a semi-mobile workshop (Figure 11) or a service truck (Figure 12) can be used to cater for the maintenance of the sand fleet.

### *Semi-mobile workshop*

A semi-mobile workshop can be used for maintenance of the sand fleet to reduce the time spent by haul trucks travelling to the workshop. It is predicted that trucks will travel a distance of 3 km on average to the semi-mobile workshop. This is because as the mine expands and the campaign mining circuits move further away, the distance to the semi-mobile workshop will increase. When the distance from the campaign mining circuits to the semi-mobile workshop is more than 4 km on average, the workshop will be moved to a location closer to the circuits.

The distance travelled by trucks going for maintenance will be reduced by a maximum of 3 km, compared with to the distance that trucks travel to the main workshop. Using the equation above, trucks will spend half the time travelling to and from the semi-mobile workshop that they did when travelling to the main workshop. This means that the maximum time saved by trucks travelling to the semi-mobile workshop will be approximately 10 minutes and 15 seconds. Figure 13 shows how the semi-mobile workshop will affect production (cumulatively).

### *Service truck*

A service truck can also be used for maintenance of the sand fleet to reduce the time spent by haul trucks travelling to the workshop. It is predicted that trucks will travel a distance of no more than 200 m for maintenance at the service truck.

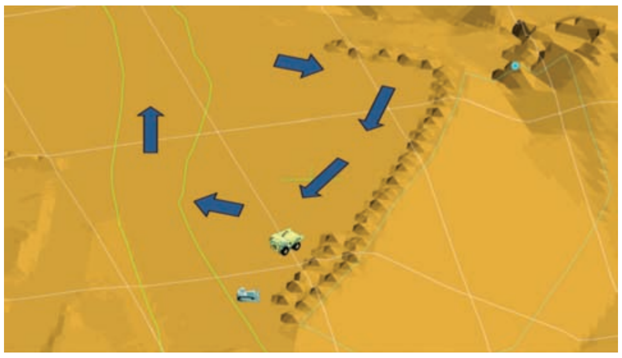


Figure 9—Improved dumping plan

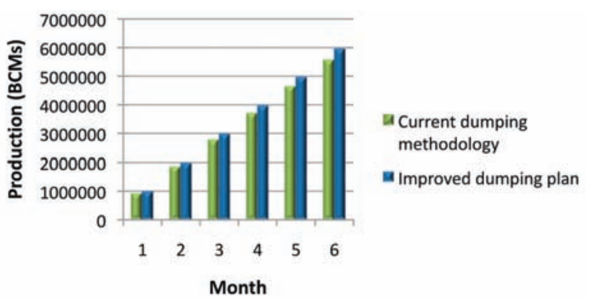



Figure 10—Effect of dumping area on production

*Table II*

**Dozer availability**

| | |
|---|---|
| Length of dumping area (m) | 132 |
| Length of heap dumped by truck (m) | 7 |
| Number of loads to fill length of dumping area | 132/7 ≈ 19 |
| Number of trucks in a circuit | 4 |
| Cycle time (s) | 683 |
| The loads dumped/truck/hour | 3600s/683s = 5 loads |
| Loads dumped/hour | 5 loads x 4 = 20 loads ≈1 row |

The distance travelled by trucks going for maintenance will be reduced by 5.8 km compared to the distance that trucks travel to go to the main workshop. Using the equation above, trucks will spend approximately 60 seconds travelling to and from the service truck. The maximum time saved will thus be approximately 19 minutes 30 seconds. Figure 13 shows how the service truck will affect production (cumulatively).

Figure 13 shows how the current workshop, semi-mobile workshop, and the service truck will contribute to production losses. The graph shows that the shorter the distance from the working area to the workshop, the less production is lost due to less time spent travelling to the workshop. Figure 13 is based on sand production during the period in which the project was conducted.

### Conclusions and recommendations

Campaign mining will improve the efficiency of the truck and shovel operation. The alternative single-sided loading method will not only reduce shovel swing angles, but spotting times will also be reduced, thus resulting in improved performance output. Campaign mining will enable continuous maintenance of haul roads, which will result in decreased cycle times as trucks do not have to slow down due to bad road conditions. The reduction in cycle times will result in increased production because trucks will be able to produce more loads per shift. Campaign mining will enable the number of stop signs in a circuit to be reduced, which will result in increased production. Campaign mining will enable the proposed dumping methodology with a dedicated entrance and exit road to be implemented. This will result in increased production because it will enable a faster and smother dumping operation, and also because the dedicated entrance and exit roads prevent trucks from using random roads for accessing the dumping area and thus requiring other trucks to give them right of way. Grading only the dedicated entrance and exit roads increases the efficiency of the grader because it will not be grading areas where the trucks will not travel. The use of a service truck as a workshop for the campaign mining fleet will be more efficient than a semi-mobile workshop or the main workshop. The service truck is more flexible than the other workshops and can travel to the campaign mining circuits to service the haul trucks, thus reducing the time haul trucks spend travelling to the workshop and increasing their productivity.

Figure 11—Semi-mobile workshop (Madonsela, 2012)


Figure 12—Service truck (Madonsela, 2012)

### Acknowledgements

The following organizations and people have been instrumental in assisting with the project in many ways. We would like to thank the management of New Vaal Colliery for providing the project and for giving permission for the results to be published. The assistance of the following individuals is also gratefully acknowledged: Shuping Makgathe, Themba Masondo, Andre de Jager, Johan van Schalkwyk, Anthony Strachan, Riaan Gilfillan, Danelle Tyler, and Natasha Ramcharan. The assistance of the School of Mining Engineering at the University of the Witwatersrand is also gratefully acknowledged.

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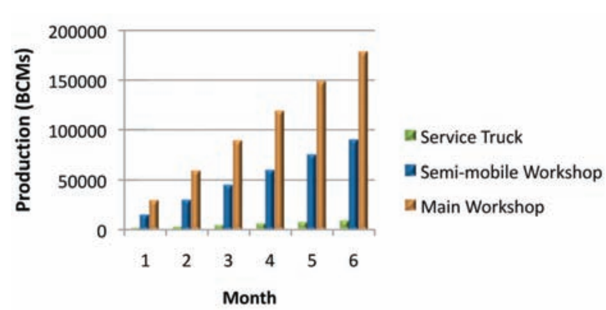


Figure 13—Production losses to due distance to workshops