CASE STUDIES: THE ENVIRONMENTAL IMPACT OF DSM PROJECTS

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ABSTRACT

The critical electricity supply situation in South Africa has brought about the implementation of DSM projects in various industries including the gold mines. However, in certain cases, this may have a negative impact on the environment. As a result of this problem a need to maximise load shifting results with minimal environmental impact has become imperative. This paper presents a study of the possible impact on the environment when attempting load shifting.

1. INTRODUCTION

South Africa is the major economic nation on the African continent [1]. Mining has been the backbone of the South African economy for more than 100 years and has contributed significantly to the economy and wellbeing of the country [1].

Waste and pollution generated from the mines is known to have a long-term impact on the environment and on the health of the people living in the surrounding regions [2]. More than 80% of South Africa's significant and hazardous waste is generated by the mining industry [2].

Due to South Africa's significant growth in electricity consumption, capacity problems has been experienced with unprecedented levels of load shedding [3]. The mining industry is a major electricity consumer in South Africa, consuming approximately 23% of the total power generated [4].

This paper will concentrate on maximizing load shifting potential while striving for minimal impact on the surrounding environment.

2. LOAD SHIFTING PROJECTS AND THE EFFECT ON WATER QUALITY

A major environmental problem relating to mining in many parts of the world is the uncontrolled discharge of contaminated water from mines [5]. This is known as acid mine drainage (AMD).

AMD water has a low pH indicating high acidity. This water contains high concentrations of sulphates, iron, and aluminium. It also contains levels of very toxic metals such as cadmium, copper, zinc and cobalt as well as other metals. Acidic water influences the soil quality and could also damage pumping infrastructure. This water could also dissolve salts and wash residues from mine dumps and other mining deposits, harming and polluting ground soil, streams, rivers and underground water [5].

As part of the DSM programme several load shifting pumping projects has been implemented on deep level gold mines. The load shifting projects results in a change in the water pumping strategies. More water is pumped during Eskom's standard and off-peak periods and less during peak periods.

Load shift for the evening peak is mandatory under the DSM programme, while morning load shift provides additional monitory savings to the client.

The possible impact of load shifting on water quality and the solutions implemented will be discussed in the following case studies.

3. CASE STUDY 1: COOKE 1 SHAFT GOLD MINE

Cooke 1 shaft is owned by Rand Uranium Mining (Pty) Ltd, and is situated in Randfontein, Gauteng province. Cooke 1 shaft has a single pump station containing four pumps. The pumps have installed capacities of 2.76MW and 3.1MW respectively. Figure 1 illustrates the dewatering system layout.

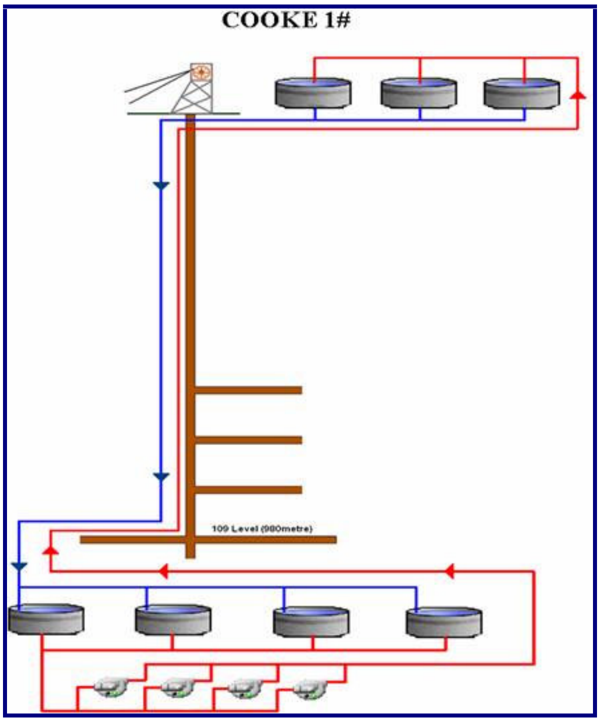

Figure 1: Cook 1# dewatering layout

The implementation of load shifting required pumps to be switched off during the peak periods. During this period the underground dams will fill up and overflow if not properly controlled. To achieve the maximum savings, more pumping should be done before peak periods in order to empty the underground dams. To impose this strategy, two pumps should operate simultaneously during Eskom's cheaper tariff periods.

However, this method could cause the surface dams to overflow and spill contaminated mine water into the surrounding streams. This mining water has high iron content as well as other mineral concentrations that increase the Electrical Conductivity (EC) which changes the water colour and causes an unpleasant smell[1].

Figure 2 shows the behaviour of the surface dams while doing load shift. It can be seen from the simulation that the dams will reach 100% of their capacity and eventually overflow before the morning and evening peak periods.

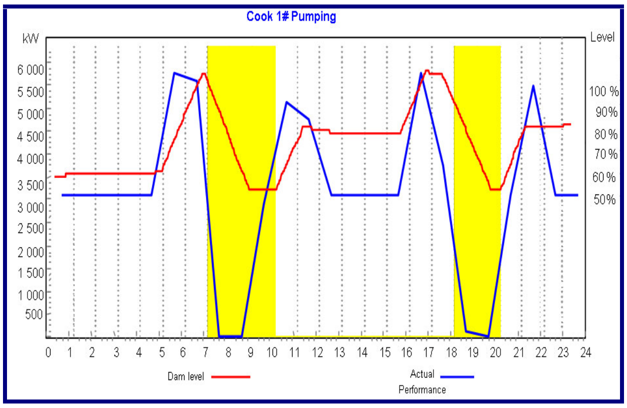

Figure 2: Surface dam level and power consumption of Cooke 1 shaft pumping system

One solution to prevent this problem was to minimise the morning peak load shift procedure and continue to pump water using just one pump. Figure 3 plots the surface dam levels after termination of morning peak load shift.

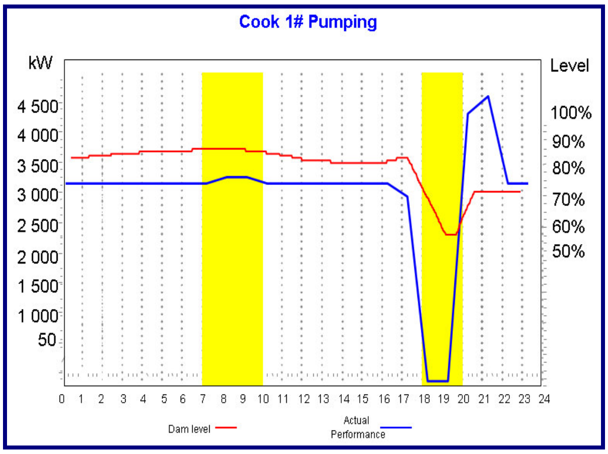

Figure 3: Surface dams levels when excluding morning peak load shift

[1] Mr. S. Keller, Environmental manager, Rand Uranium environmental department, Randfontein, Gauteng.

As a result of this change in DSM schedule, the mine will lose an average of 2.31MW daily savings during the morning peak. However, pollution of the surrounding areas will be prevented. In this instance the maximum evening load shift could still be achieved. The nett impact is shown in Table 1.

Table 1: Cook 1 shaft load shift results

Cook 1#	Environmental impact not considered (MW)	Environmental impact considered (MW)	Nett Impact (MW)
Morning Load Shift	2.31	0	-2.31
Evening Load Shift	2.31	2.31	0

4. CASE STUDY 2: GROOTVLEI 3 SHAFT GOLD MINE

Grootvlei 3 shaft mine is owned by Pamodzi Pty Ltd, and is situated in Springs, Gauteng province. Figure 4 shows the layout of the pumping system.

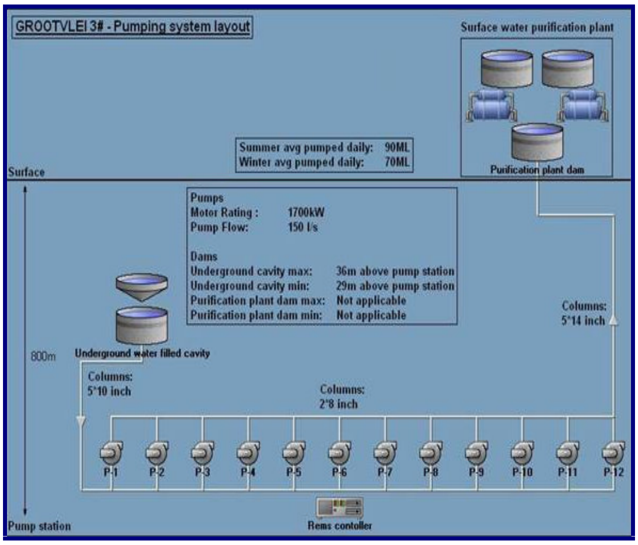

Figure 4: Layout of Grootvlei 3 shaft pump station

At Grootvlei 3 shaft, mining operations were ceased and the mine is only pumping underground water. It consists of only one pump station with 12 pumps. Each pump has an installed capacity of 1.7MW.

Underground water is pumped from a large underground cavity linking surrounding mines. The cavity water level must be kept below 36.9m to prevent flooding of the neighbouring mines. During summer periods Grootvlei 3 shaft needs to pump an average of 80Ml per day to limit the cavity level from rising.

Underground water extracted from Grootvlei 3 shaft contains high iron, ferrous and other sulphate concentrations which reduces the pH level to less than 4 [6]. This water therefore needs to be chemically treated before being allowed to flow into the nearby Blesbokspruit.

After the water is pumped from underground and reaches surface treatment starts. Oxygen is first added to the water through the delivery column. This process changes the ferrous or iron(II) cations, in solution to ferric or iron(III) cations. Lime is then added which combines with the iron(III) ions. In the final stage a flocculent is added to deposit the residues on the bottom of the settler dams. The clear water on top is then allowed to drain into the Blesbokspruit stream.

This treatment process is accomplished by using dosing pumps which integrate with the load shifting schedule. During peak periods when all the pumps are turned off, the iron content of the water increases to unacceptable levels of 4 ppm (parts per million). Figure 5 shows the data obtained over different days and the significant iron content increase during the peak time period while the pumps were off.

This very high iron concentration requires a longer time and larger amounts of lime to reduce the concentration to the acceptable level of 1ppm. This results in an increased cost to the mine. The high concentration of iron components in the water also increases the EC. This causes further contamination of the water making it even more harmful to the environment[2].

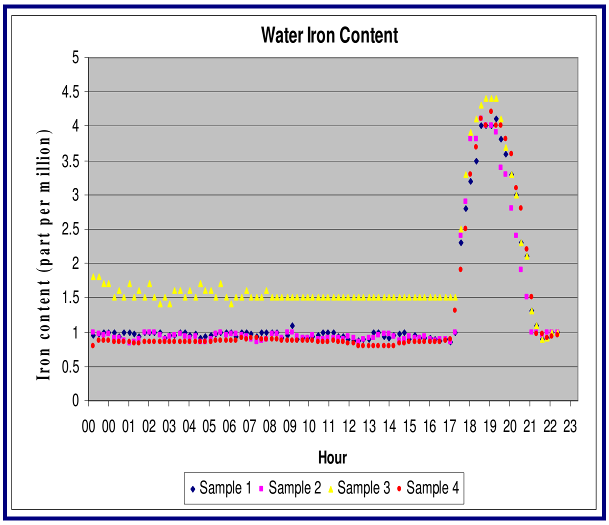

Figure 5: Iron contents rise up during peak time

The solution to this problem was to keep one pump running during peak time. With one pump in operation the iron concentration rises to about 1.4ppm during the peak period which is still higher than the acceptable amount of iron but easier and faster to treat and causes a minimal negative environmental impact.

A loss of 1.7MW in DSM savings, during the evening peak, resulted from the single pump operation. The average savings will now only be 7.8 MW per day as opposed to the 9.5 MW anticipated through simulation. The environmental impact outweighs the financial and DSM impacts. The nett impact is shown in Table 2.

[2] Mr. J. Botha, Chief foreman, Grootvlei 3#, Springs, east rand, Gauteng.

Table 2: Grootvlei 3 shaft load shift results

Grootvlei 3#	Environmental impact not considered (MW)	Environmental impact considered (MW)	Nett Impact (MW)
Morning Load Shift	1.5	1.5	0
Evening Load Shift	9.5	7.8	-1.7

5. CASE STUDY 3: KLOOF 10 SHAFT GOLD MINE

Kloof 10 shaft is operated by Goldfield (Pty) Ltd, and is located in Westonaria, Gauteng province. Mining operations was also ceased at this mine and the shaft is only being used to pump water. Figure 6 illustrates the mine layout. A DSM project was implemented at this mine with a target to shift 7 MW daily.

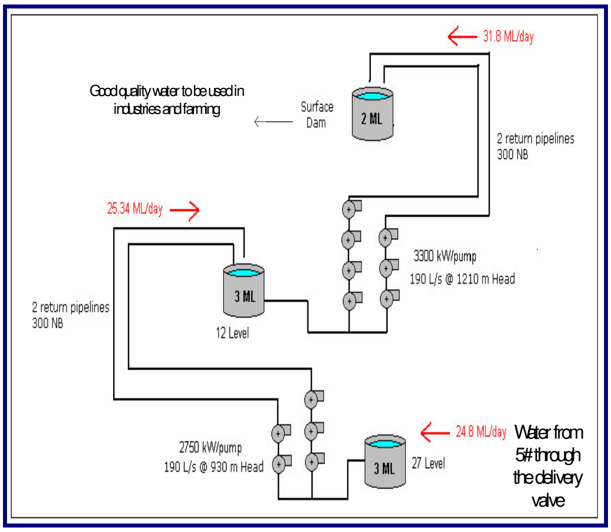

Figure 6: Kloof 10 shaft pump system layout

As shown in the Figure 6, the mine has two pump stations:

- 27 level pump station has 5 pumps. Each pump is rated at 2.75MW. The total underground dam capacity is 3 ML.
- 12 level pump station has 7 pumps. Each pump is rated at 3.30MW. The total underground dam capacity is 2 ML on this level.

Water flows from Kloof 5 shaft to Kloof 10 shaft through a tunnel that connects the 10 shaft and underground cavity situated at Kloof 5 shaft. This water then passes through a plug valve that is situated at the end of the tunnel at 27 level pump station.

The main water source that feeds 27 level pump station flows through this plug valve. The water is then pumped via 12 level to the surface reservoirs where it flows to the nearby farms. Figure 7 shows the 27 level plug valve at Kloof 10 shaft.

Figure 7: 27 level plug valve at Kloof 10 shaft

This plug valve is a very important component when determining the maximum load shift potential as well as determining the quality of the water passing through the valve. The plug valve is a butterfly type valve and controls the flow of the water into 27 level pump station. The water quality is greatly affected by the Kloof 5 shaft cavity height level. Figure 8 shows the relation between the water level, water pH and the EC.

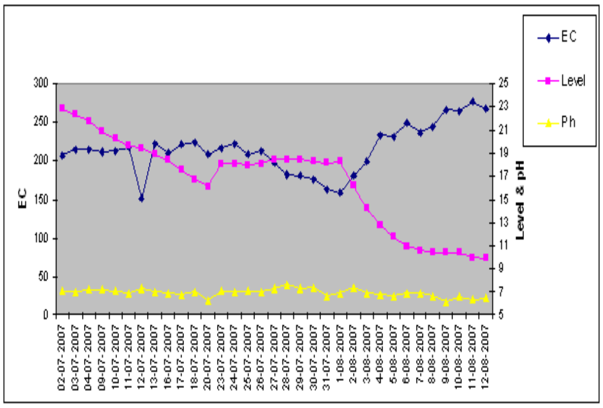

Figure 8: Variation in EC vs. the Kloof 5 shaft cavity level

It can be seen from Figure 8 that the EC increases dramatically when the cavity level decreases below 18%. This contaminated water will cause great damage to the pumps, discharge valves and the water columns. When this water reaches the surface it has an adverse affect on the farmlands[3].

Before the DSM project was implemented, the plug valve was kept partially open at a fixed value of 24%. This was done to maintain the water level of the cavity at Kloof 5 shaft at a specific level. This procedure ensured an acceptable quality of inlet water.

After the successful implementation of the DSM project, it was realised that by keeping the valve opened at a fixed setpoint, limits the amount of savings for the mine. The average load shift with the valve 24% open was only 5.52MW.

In order to increase load shift and cost savings, the plug valve needs to be controlled. Figure 9 shows the percentage opening of the valve and the corresponding water flow rate. By altering the valve opening throughout the day, the amount of load shift and cost savings could be increased.

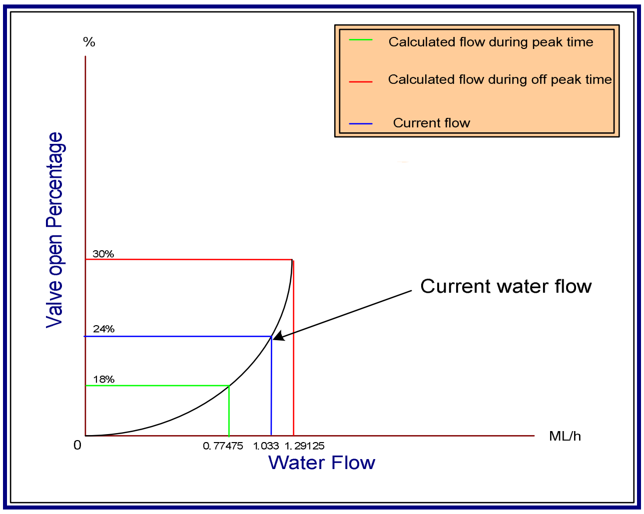

Figure 9: 27 level plug valve % opening and flow rate

As mentioned before, the valve was previously set at 24% opening. Simulations however showed that by modulating the valve between 16% and 30% throughout the day, maximum load shift would be achieved without influencing the water quality. After this technique was applied, the flow though the valve decreased during peak time.

This made it possible to turn all the pumps off during the evening peak period. However, to make up for the reduced flow rate, the water flow after peak periods needs to be increased, to keep the cavity level constant.

By controlling the valve opening, the evening load shift increased to an average of 6.8MW. The EC of the water remained stable and water quality was preserved. The nett impact is shown in Table 3.

Table 3: Kloof 10 shaft load shift results

Kloof 10#	Load shift during normal operations-environmental impact considered (MW)	Load shift after process optimisation-environmental impact considered (MW)	Nett Impact (MW)
Morning Load Shift	3	3	0
Evening Load Shift	5.52	7.8	2.28

6. CONCLUSION AND RECOMMENDATIONS

From the case studies it was concluded that load shifting projects may have a direct impact on the environment. In some cases the maximum load shift potential might not be achieved without impacting the environment negatively. Whenever DSM initiatives are being planned, it is always

[3] Mr. J. Lancaster, Goldfields environmental department, Libanon, Guateng.

recommended that a comprehensive environmental impact assessment first be completed.

It was also shown that the DSM results could actually be increased when integrating the environmental management with a DSM load shifting project.

7. REFERENCES

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